National Park Service
U.S. Department of the Interior

Natural Resource Stewardship and Science

Natural Resource Condition Assessment

Flight 93 National Memorial

Natural Resource Report NPS/FLNI/NRR—2020/2059

ON THE COVER
Flight 93 National Memorial Visitors Center Wall overlooking the Field of Honor
Image credit NPS/Brenda Torrey

Natural Resource Condition Assessment

Flight 93 National Memorial

Natural Resource Report NPS/FLNI/NRR—2020/2059

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Executive Summary

In collaboration with the National Park Service, the Western Pennsylvania Conservancy (WPC) completed the Natural Resource Condition Assessment (NRCA) for Flight 93 National Memorial (FLNI). The purpose of the NRCA is to provide park leaders and resource managers with information on resource conditions to support near-term planning and management, long-term strategic planning, and effective science communication to decision-makers and the public.

Flight 93 National Memorial is a 2,277 acre memorial located in Somerset County in southwest Pennsylvania, near Shanksville, PA. The park marks the crash location where, on the morning of September 11, 2001, passengers and crew of hijacked United States Flight 93 selflessly thwarted a planned attack on Washington, D.C. The park was created a year after the crash, September 24, 2002, with the passing of The Flight 93 National Memorial Act (P.L. 107-226). This Act authorized the creation of the park and established the Flight 93 Advisory Commission. The purpose of the park is to honor the passengers and crew members of Flight 93 who courageously gave their lives, allow the public to visit the site and express their feelings about the event and the passengers and crew of Flight 93, and to preserve the solemn and tranquil setting of the crash site of Flight 93.

Flight 93 National Memorial is a unique park in that its resources are a combination of culturally significant features to honor the passengers and crew of Flight 93 (Flight 93 National Memorial, Boulder, Hemlock Grove, Impact Site, The Allee and Memorial groves, The Wall of Names, and the Visitor Center Complex) and natural resources that make up the surrounding landscape setting. With the help of both FLNI and National Park Service (NPS) staff, the resources of greatest importance to FLNI were selected for inclusion in the NRCA and are listed below as five focal areas and associated indicators (in parentheses): air quality (ozone, visibility, and wet deposition), night sky and acoustic quality (night sky and soundscape), stream water quality (water chemistry, and aquatic macroinvertebrates), biological quality (birds, pollinators, mammals, and herpetofauna and fish), and ecological quality (natural communities and culturally significant communities).

Natural resources were assessed using the framework established by NPS for NRCA development and is described in detail in Chapter 3. For each natural resource, one or more indicators were identified (listed above) along with metrics by which each indicator was assessed. Available data were compiled for each indicator/metric to establish a baseline of reference conditions and a means to determine the current condition/status (good, moderate concern, or significant concern). Since FLNI is not yet part of a larger monitoring network established by NPS, no standardized baseline data exists for assessing resource conditions. Instead, much of the supporting science used to assess park resources for this NRCA were derived from larger, regional data sets (i.e., air quality and night sky and acoustic quality) and from FLNI specific projects (e.g., a bee study at FLNI, plant community mapping of FLNI, and water quality from stream monitoring stations associated with mine reclamation activities) (see Section 2.3.2 Table 2-3 for data sources for all resources).

Available data were also used to determine the trend in condition (improving, unchanging, or deteriorating) and confidence of the assessment (high, medium, low). Due to the lack of baseline or monitoring data, it was often impossible to determine trends for indicators. Condition, trend, and

confidence scores for each resource indicator were presented in tabular form using standardized symbology (see Section 3.2.1 Tables 3-1 and 3-2). Each resource assessment is detailed in Chapter 4 and summarized in the following paragraphs.

Air Quality

Air Quality at FLNI is of moderate concern and is consistent with air quality reports from other regional NPS sites in southwest Pennsylvania. Ozone, visibility, and wet deposition were the indicators used to assess air quality. Ground-level ozone at FLNI was scored using two metrics established by the Environmental Protection Agency (EPA) Air Quality System database (AQS), air quality condition for human health and air quality for plant health. Based on these metrics, ozone conditions at FLNI warrant moderate concern. Metrics for ground-level ozone were estimated at FLNI using spatial interpolation methods, which reduces confidence in these estimates. Trend data are no available for ozone metrics. On-site monitoring stations would improve estimates of ground-level ozone at FLNI. See Section 4.1.1 for more detail.

Visibility at FLNI was scored using haze index as the metric. Estimates of the haze index suggest moderate concern for visibility at FLNI. However, trend analysis suggests that visibility conditions are improving. The haze index was calculated from data collected at FLNI or a nearby sampling location, and these data have a rating of high confidence. See Section 4.1.2 for more detail.

Nitrogen, sulfur, and mercury deposition were all considered metrics for wet deposition. Estimates of nitrogen and sulfur deposition warrant significant concern at FLNI. Estimates of mercury wet deposition and predicted methylmercury concentration warrant moderate concern at FLNI. Data for these metrics were estimated based on an interpolated data set provided by the National Park Service Air Resources Division (NPS ARD) and had a medium confidence level because of this. No trend data was available because no monitoring data is currently being collected at FLNI. See Section 4.1.3 for more detail.

Night Sky and Soundscape

Night Sky at FLNI is in good condition and was scored using ambient light ratio (ALR) as the metric. Ambient light ratio is the ratio of natural light to ambient light and is the recommended metric for assessing night sky. Confidence was medium because estimates were obtained through an interpolated regional dataset provided by NPS Natural Sounds and Night Sky Division (NPS NSNSD). No trend data was available due to lack monitoring data being collected at FLNI. See Section 4.2.1 for additional details.

Soundscape at FLNI warrants significant concern. L50 dBA impact score was the metric used to score this resource. Since no ambient sound monitoring is currently being conducted at FLNI, the results of a sound model developed by NPS NSNSD were used to score sound conditions at the Park instead. Confidence in the L50 dBA score was considered medium because the score was based on interpolation. No trend data was available due to lack of monitoring for this resource at FLNI. See Section 4.2.2 for more details about the assessment.

Stream Water Quality

Stream water quality was evaluated using water chemistry as an indicator. Alkalinity, aluminum, iron, and pH were the water chemistry metrics used to determine water quality at one monitoring station (LRS-30) on Lamberts Run within FLNI. Based on 2009 water quality data, the water quality of Lamberts Run, downstream of the passive acid mine drainage (AMD) treatment system, is in good condition and improving according to PA water chemistry standards (PA Code §93.7). Trend in data from 2001–2009 show consistent improvement of water quality conditions at LRS-30. Unfortunately, monitoring efforts were discontinued after 2009 at the only monitoring station on Lamberts Run within FLNI. Future efforts should be made to reestablish monitoring at this site and implement monitoring at Grove Run. Grove Run also originates within FLNI boundaries but is not currently monitored. See Section 4.3.1 for more assessment details.

Aquatic macroinvertebrates were identified as an important indicator of stream water quality for inclusion in the NRCA. Unfortunately, no data sources were available to evaluate this indicator. Although no data are currently available, aquatic macroinvertebrates was left in the stream water quality section because it represents a data gap and would be an important component to add to future water quality monitoring efforts.

Biological Quality

Biological quality was assessed using the following taxonomic groups as indicators: birds, pollinators, mammals, and herpetofauna and fish. For birds, the presence of obligate grassland bird species and bird habitat conservation value scores were used as metrics for assessing the condition and trend of the biological quality of the grassland bird community at FLNI. Grassland bird communities and grassland habitat are in good condition at FLNI. Trend could not be scored due to lack of available data. No data exist to evaluate forest generalist or forest interior bird communities. See Section 4.4.1 for more information about the assessment.

Presence of cleptoparasitic guild was used as a metric for the biological quality of pollinators. As an important component of the pollinator community, bee species are in good condition at FLNI. Pollinator trend could not be determined due to insufficient data. Data is lacking for other pollinator species at FLNI. See Section 4.4.2 for more assessment details.

Mammals were identified as an important indicator of biological quality at FLNI. However, bat data was the only mammal data available for FLNI and it was very limited with no scorable metrics. Therefore, condition and trend could not be scored for mammals at FLNI. Although no data are currently available, mammals were left in the biological quality section because they represent data gaps and would be important to add to future biological monitoring efforts at FLNI. See Section 4.4.3 for more information about the bat data collected at FLNI.

Like mammals, herpetofauna (reptiles and amphibians) and fish were identified as important indicators of biological quality at FNLI. However, data is not available for these taxonomic groups to score current conditions and trends. The only data source for FLNI is a species list with occurrence ranks for reptiles. Although no data are currently available, herpetofauna and fish were left in the

biological quality section because they represent data gaps and would be important to add to future biological inventory efforts at FLNI.

Ecological Quality

Since FLNI consists of both culturally significant features to honor the passengers and crew of Flight 93 and more natural communities that make up the landscape of the Park, both were considered as indicators when evaluating the ecological quality of FLNI. Twenty-two plant communities were identified, mapped, and described at FLNI; nine natural community types (seven upland and 2 wetland), nine successional or modified (managed) types, and four non-natural types (highly disturbed and/or permanently modified features typically not supporting vegetation). A Landscape Condition Model (LCM) for Pennsylvania was used to assign landscape condition scores to the different plant community types. The scores were then used as the metric to assess the condition of plant communities at FLNI from a landscape perspective relative to nearby anthropogenic disturbance. Plant community data for FLNI was used to estimate the cover of native plant species in each community type which was then used as the metric to score the condition of plant community composition. The condition of natural and successional communities at FLNI varies considerably across FLNI and reflects a variety of intense historical human uses including strip mining, logging, and farming. See Section 4.5.1 for a more detailed explanation of the methods used in the assessment and the condition of specific plant community types.

Specific landscape units containing culturally significant features were mapped and evaluated with the same metrics applied to natural community and successional land cover patches at FLNI. The culturally significant features include six areas: the Allee and Memorial Groves, Visitor Center Complex, Tower of Voices, Hemlock Grove, Impact Site (approximation), and the Memorial. Landscape context condition scores for the six landscape units possessing culturally significant features at FLNI indicate that all but one (Hemlock Grove) are of moderate concern. Except for the Hemlock Grove, all other features occur on reclaimed strip mine land and are routinely managed. The Hemlock Grove is the most “natural” of all culturally significant features and was given a landscape context condition score of good.

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NRCA Background Information

Natural Resource Condition Assessments (NRCAs) evaluate current conditions for a subset of natural resources and resource indicators in national park units, hereafter "parks." NRCAs also report on trends in resource condition (when possible), identify critical data gaps, and characterize a general level of confidence for study findings. The resources and indicators emphasized in a given project depend on the park's resource setting, status of resource stewardship planning and science in identifying high-priority indicators, and availability of data and expertise to assess current conditions for a variety of potential study resources and indicators.

NRCAs Strive to Provide…

- *Credible condition reporting for a subset of important park natural resources and indicators*
- *Useful condition summaries by broader resource categories or topics, and by park areas*

NRCAs represent a relatively new approach to assessing and reporting on park resource conditions. They are meant to complement—not replace—traditional issue-and threat-based resource assessments. As distinguishing characteristics, all NRCAs:

- Are multi-disciplinary in scope;[1]
- Employ hierarchical indicator frameworks;[2]
- Identify or develop reference conditions/values for comparison against current conditions;[3]
- Emphasize spatial evaluation of conditions and GIS (map) products; [4]
- Summarize key findings by park areas; and [5]
- Follow national NRCA guidelines and standards for study design and reporting products.

Although the primary objective of NRCAs is to report on current conditions relative to logical forms of reference conditions and values, NRCAs also report on trends, when appropriate (i.e., when the underlying data and methods support such reporting), as well as influences on resource conditions. These influences may include past activities or conditions that provide a helpful context for

[1] The breadth of natural resources and number/type of indicators evaluated will vary by park.

[2] Frameworks help guide a multi-disciplinary selection of indicators and subsequent "roll up" and reporting of data for measures ⇨ conditions for indicators ⇨ condition summaries by broader topics and park areas

[3] NRCAs must consider ecologically-based reference conditions, must also consider applicable legal and regulatory standards, and can consider other management-specified condition objectives or targets; each study indicator can be evaluated against one or more types of logical reference conditions. Reference values can be expressed in qualitative to quantitative terms, as a single value or range of values; they represent desirable resource conditions or, alternatively, condition states that we wish to avoid or that require a follow-up response (e.g., ecological thresholds or management "triggers").

[4] As possible and appropriate, NRCAs describe condition gradients or differences across a park for important natural resources and study indicators through a set of GIS coverages and map products.

[5] In addition to reporting on indicator-level conditions, investigators are asked to take a bigger picture (more holistic) view and summarize overall findings and provide suggestions to managers on an area-by-area basis: 1) by park ecosystem/habitat types or watersheds, and 2) for other park areas as requested.

understanding current conditions, and/or present-day threats and stressors that are best interpreted at park, watershed, or landscape scales (though NRCAs do not report on condition status for land areas and natural resources beyond park boundaries). Intensive cause-and-effect analyses of threats and stressors, and development of detailed treatment options, are outside the scope of NRCAs.
Due to their modest funding, relatively quick timeframe for completion, and reliance on existing data and information, NRCAs are not intended to be exhaustive. Their methodology typically involves an informal synthesis of scientific data and information from multiple and diverse sources. Level of rigor and statistical repeatability will vary by resource or indicator, reflecting differences in existing data and knowledge bases across the varied study components.

The credibility of NRCA results is derived from the data, methods, and reference values used in the project work, which are designed to be appropriate for the stated purpose of the project, as well as adequately documented. For each study indicator for which current condition or trend is reported, we will identify critical data gaps and describe the level of confidence in at least qualitative terms. Involvement of park staff and National Park Service (NPS) subject-matter experts at critical points during the project timeline is also important. These staff will be asked to assist with the selection of study indicators; recommend data sets, methods, and reference conditions and values; and help provide a multi-disciplinary review of draft study findings and products.

NRCAs can yield new insights about current park resource conditions, but, in many cases, their greatest value may be the development of useful documentation regarding known or suspected resource conditions within parks. Reporting products can help park managers as they think about near-term workload priorities, frame data and study needs for important park resources, and communicate messages about current park resource conditions to various audiences. A successful NRCA delivers science-based information that is both credible and has practical uses for a variety of park decision making, planning, and partnership activities.

Important NRCA Success Factors

- *Obtaining good input from park staff and other NPS subject-matter experts at critical points in the project timeline*
- *Using study frameworks that accommodate meaningful condition reporting at multiple levels (measures ⇨ indicators ⇨ broader resource topics and park areas)*
- *Building credibility by clearly documenting the data and methods used, critical data gaps, and level of confidence for indicator-level condition findings*

However, it is important to note that NRCAs do not establish management targets for study indicators. That process must occur through park planning and management activities. What an NRCA can do is deliver science-based information that will assist park managers in their ongoing, long-term efforts to describe and quantify a park's desired resource conditions and management

targets. In the near term, NRCA findings assist strategic park resource planning[6] and help parks to report on government accountability measures.[7] In addition, although in-depth analysis of the effects of climate change on park natural resources is outside the scope of NRCAs, the condition analyses and data sets developed for NRCAs will be useful for park-level climate-change studies and planning efforts.

NRCAs also provide a useful complement to rigorous NPS science support programs, such as the NPS Natural Resources Inventory & Monitoring (I&M) Program.[8] For example, NRCAs can provide current condition estimates and help establish reference conditions, or baseline values, for some of a park's vital signs monitoring indicators. They can also draw upon non-NPS data to help evaluate current conditions for those same vital signs. In some cases, I&M data sets are incorporated into NRCA analyses and reporting products.

NRCA Reporting Products…

Provide a credible, snapshot-in-time evaluation for a subset of important park natural resources and indicators, to help park managers:

- *Direct limited staff and funding resources to park areas and natural resources that represent high need and/or high opportunity situations* ***(near-term operational planning and management)***
- *Improve understanding and quantification for desired conditions for the park's "fundamental" and "other important" natural resources and values* ***(longer-term strategic planning)***
- *Communicate succinct messages regarding current resource conditions to government program managers, to Congress, and to the general public* ***("resource condition status" reporting)***

Over the next several years, the NPS plans to fund an NRCA project for each of the approximately 270 parks served by the NPS I&M Program. For more information visit the NRCA Program website.

[6] An NRCA can be useful during the development of a park's Resource Stewardship Strategy (RSS) and can also be tailored to act as a post-RSS project.

[7] While accountability reporting measures are subject to change, the spatial and reference-based condition data provided by NRCAs will be useful for most forms of "resource condition status" reporting as may be required by the NPS, the Department of the Interior, or the Office of Management and Budget.

[8] The I&M program consists of 32 networks nationwide that are implementing "vital signs" monitoring in order to assess the condition of park ecosystems and develop a stronger scientific basis for stewardship and management of natural resources across the National Park System. "Vital signs" are a subset of physical, chemical, and biological elements and processes of park ecosystems that are selected to represent the overall health or condition of park resources, known or hypothesized effects of stressors, or elements that have important human values.

Introduction and Resource Setting

Introduction

Enabling Legislation

Flight 93 National Memorial (FLNI) was created to "commemorate the passengers and crew of Flight 93 who, on September 11, 2001, courageously gave their lives thereby thwarting a planned attack on our Nation's Capital". That morning, the United States came under attack when commercial airliners were hijacked. Two airliners departed from Boston's Logan International Airport and were flown into the World Trade Center towers in New York City, NY. A third airliner departed from Washington Dulles International Airport and struck the Pentagon in Arlington, VA. The fourth airliner (Flight 93) was intended to fly from Newark International Airport in New Jersey to San Francisco, CA. About 45 minutes into the flight, the plane was redirected toward Washington, D.C. The passengers and crew acted selflessly and avoided a fourth attack. Flight 93 tragically crashed in an empty field near Shanksville, PA where all on board were killed.

The significance of the crash location for Flight 93 was quickly realized by local and national officials. On September 24, 2002, only a year after the September 11, 2001 attacks, the United States Congress passed The Flight 93 National Memorial Act (P.L. 107-226). This authorized the creation of the memorial and established the Flight 93 Advisory Commission.

The enabling legislation for *The Flight 93 National Memorial Act* includes shared understandings about the purpose of the park:

- *Honor the passengers and crew members of Flight 93 who courageously gave their lives, thereby thwarting a planned attack on Washington, D.C.*
- *Allow the public to visit the site and express their feelings about the event and the passengers and crew of Flight 93*
- *Respect the rural landscape and preserve the solemn and tranquil setting of the crash site of Flight 93*

The heroic efforts of the passengers and crew have been honored at Flight 93 National Memorial. FLNI contains multiple cultural and natural resources, including the Visitor Center Complex, the Memorial Plaza, the Tower of Voices, and Hemlock Grove. These resources reflect the courageous effort of passengers and crew aboard Flight 93 and provide a tranquil landscape which will forever be memorialized as a result of this tragedy.

Geographic Setting

FLNI is located in Somerset County in southwest Pennsylvania (Figure 2-1). The proclamation boundary contains 2,277 acres, and approximately 1,640 acres are owned by the United States government. Nearby cities include Somerset, which has a population of approximately 6,000 people, and Johnstown, with a population of about 20,000 people. Somerset County is like the surrounding counties with regards to population size, age structure, income, and other indicators of economic status (median home value, civilian labor force; Table 2-1; US Census Bureau 2019). In terms of

land area, Somerset County is larger than Cambria, Fayette, and Bedford Counties (Table 2-1). Somerset County has a population size of approximately 74,000 (US Census Bureau 2019), which is lower than that of Cambria and Fayette Counties (Table 2-1; Figure 2-1). Population density of Somerset is approximately 72.4 people/sq. mile, substantially lower than that of Fayette and Cambria Counties (Table 2-1; US Census Bureau 2019); this is expected given the lower overall population size and larger land area of Somerset County. Somerset County has experienced recent declines in population size (-4.2%) like surrounding counties. Approximately 21% of the population of Somerset County is over the age of 65, and the age structure of Somerset County is very similar to that of surrounding counties (Table 2-1). Median household income in Somerset County is approximately $46,000 per year, which is also consistent with Cambria, Fayette, and Bedford Counties (Table 2-1).

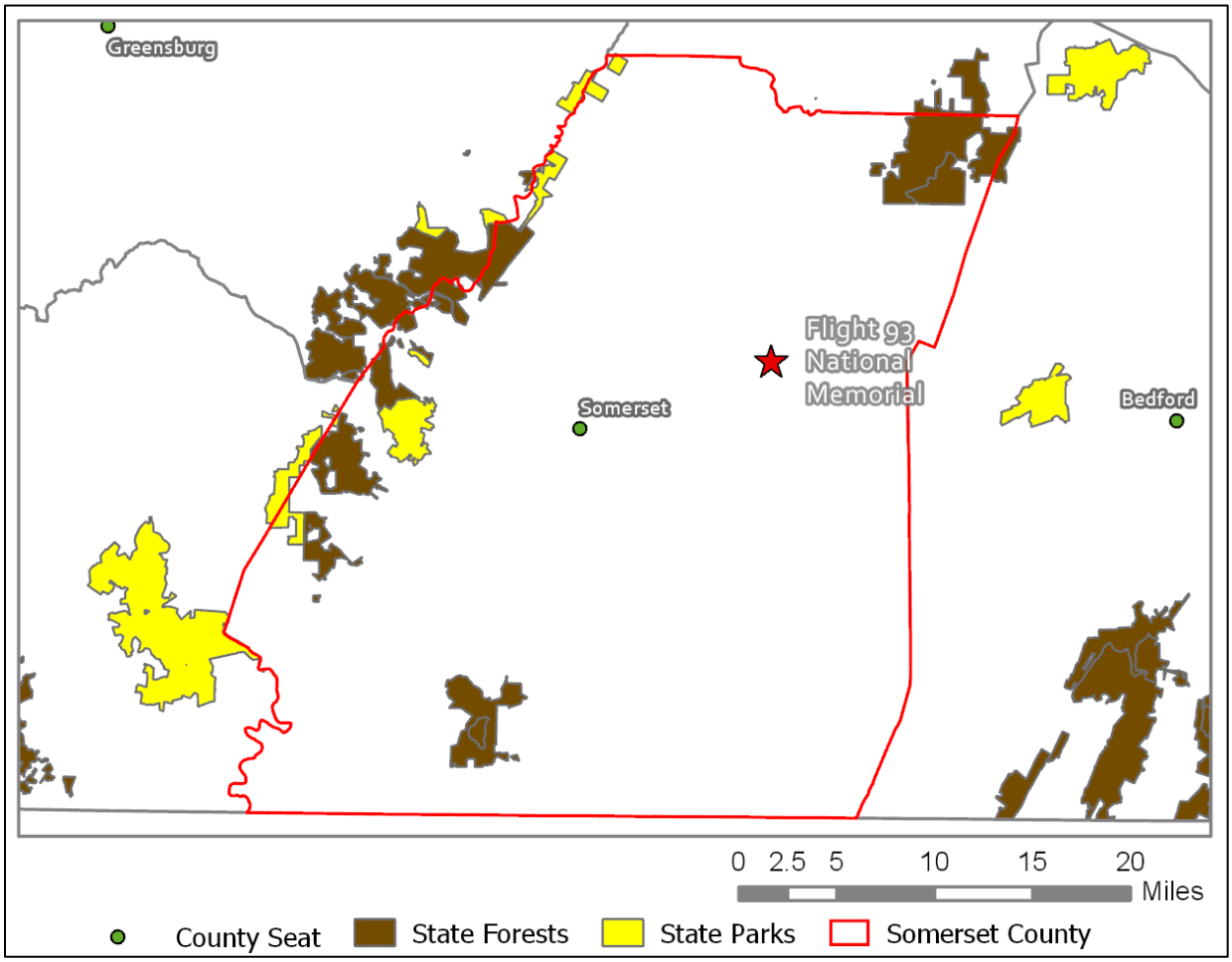


Figure 2-1. Location of Flight 93 National Park relative to public lands and major cities (county seats) in and around Somerset County, Pennsylvania.

Table 2-1. Demographic and economic data from US Census Bureau (accessed February 25, 2019) for Somerset and surrounding counties.

Category	Data Type	Somerset	Bedford	Cambria	Fayette
County Size	Land area in square miles, 2010	1,074.37	1,012.30	688.35	790.34
Population	Population, 2010 census	77,742	49,762	143,679	136,606
	Population, 2017 estimates	74,501	48,480	133,054	131,504
	Population, est. percent change	-4.20%	-2.60%	-7.40%	-3.70%
	Population per sq. mi., 2010	72.4	49.2	208.7	172.8
Age	Persons under 5 years, percent	4.60%	4.80%	4.90%	5.20%
	Persons under 18 years, percent	18.10%	19.50%	19.20%	19.30%
	Persons 65 years and over, percent	21.90%	22.50%	22.00%	20.60%
Housing	Owner-occupied housing unit rate, 2013–2017	77.90%	79.50%	74.30%	73.00%
	Median value, owner-occupied housing units, 2013–2017	$103,100	$126,800	$88,900	$94,600
	Median gross rent, 2013–2017	$607	$658	$604	$624
Households	Households, 2013–2017	29,918	19,666	57,154	54,043
	Persons per household, 2013–2017	2.36	2.46	2.24	2.38
	Households with broadband Internet, 2013–2017	67.70%	69.00%	71.80%	67.90%
Education	High school graduate or higher, percent of persons age 25 years+, 2013–2017	87.80%	87.00%	90.80%	87.90%
	Bachelor's degree or higher, percent of persons age 25 years+, 2013–2017	15.70%	13.80%	20.90%	15.40%
Employment	In civilian labor force, total, percent of population age 16 years+, 2013–2017	55.10%	58.40%	55.00%	53.00%
	Total employer establishments, 2016	1,686	1,074	3,171	2,604
	Total employment, 2016	18,295	12,856	46,970	35,982
	Total employment, percent change, 2015–2016	-1.40%	-2.70%	0.90%	-3.90%
Economic Indicators	Total retail sales per capita, 2012	$10,150	$11,682	$12,246	$12,081
	Mean travel time to work (minutes), workers age 16 years+, 2013–2017	24.2	27.2	24.1	26.3
	Median household income (in 2017 dollars), 2013–2017	$46,132	$48,703	$44,943	$41,632

Table 2-1 (continued). Demographic and economic data from US Census Bureau (accessed February 25, 2019) for Somerset and surrounding counties.

Category	Data Type	Somerset	Bedford	Cambria	Fayette
Economic Indicators (continued)	Per capita income in past 12 months (in 2017 dollars), 2013–2017	$23,877	$24,219	$24,838	$24,247
	Persons in poverty, percent	12.60%	12.30%	15.00%	17.90%

Historical Land Use

Over the past 200 years, natural habitats of southwestern Pennsylvania have experienced widespread, anthropogenic disturbance. Most of Pennsylvania's forests had been harvested by the late 1800s, and many early successional habitats that resulted from deforestation were developed for agriculture or other non-natural land uses. Western Pennsylvania has a legacy of bituminous coal mining that continues today with active deep mines and surface mines in the region (Figure 2-2). Many areas disturbed by surface mining after the 1970s (following the Surface Mining Control and Reclamation Act of 1977 (SMCRA)) have been revegetated (often referred to as mine site reclamation or reclaimed mine sites), but reclamation methods and success of ecological restoration have varied across Pennsylvania. Mining is particularly relevant to the landscape of FLNI. At the time of the September 11, 2001 attacks, the site was an active mine (that closed in 2003) and was highly disturbed.

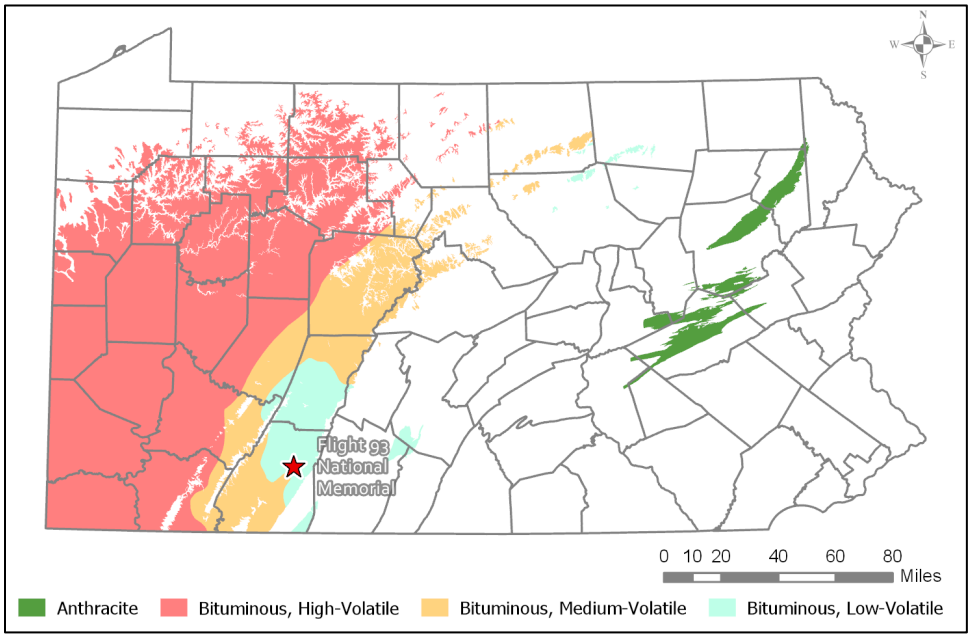


Figure 2-2. The location of legacy and current coal fields in Pennsylvania. Flight 93 National Memorial occurs near the edge of the bituminous coal fields in western Pennsylvania.

Visitation Statistics

On average, FLNI has received approximately 260,000 visitors annually (Figures 2-3 through 2-5). The majority of park visits occur during the month of September (Figures 2-3 through 2-5), and total annual visitation has increased steadily since the addition of the permanent memorial in 2011 (Figure 2-5).

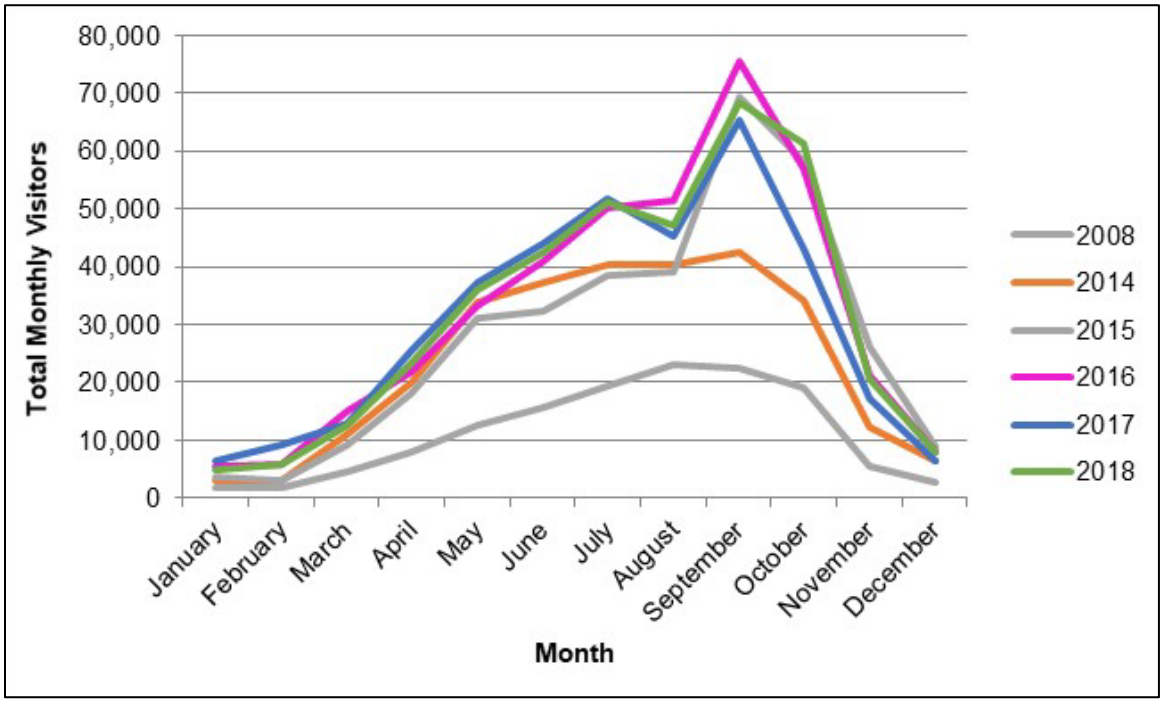


Figure 2-3. Visitation to Flight 93 National Memorial by month for the years 2008 (oldest complete dataset for park visitation) and 2014–2018 (NPS-IRMA 2019).

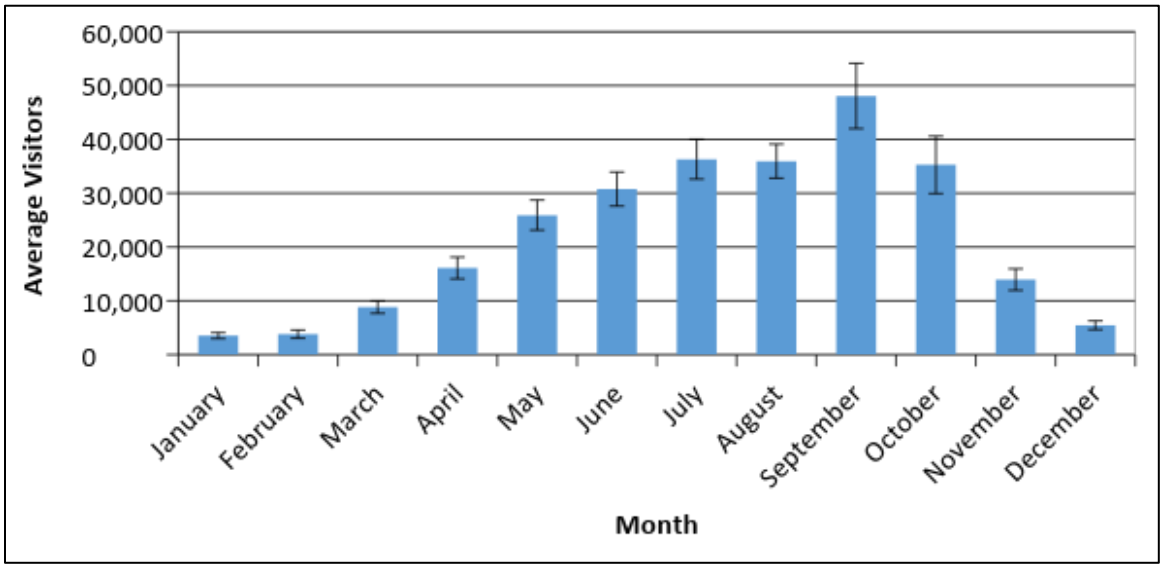


Figure 2-4. Average monthly visitation at Flight 93 National Memorial from 2008 to 2018 (NPS-IRMA 2019). Standard error is presented (black bars).

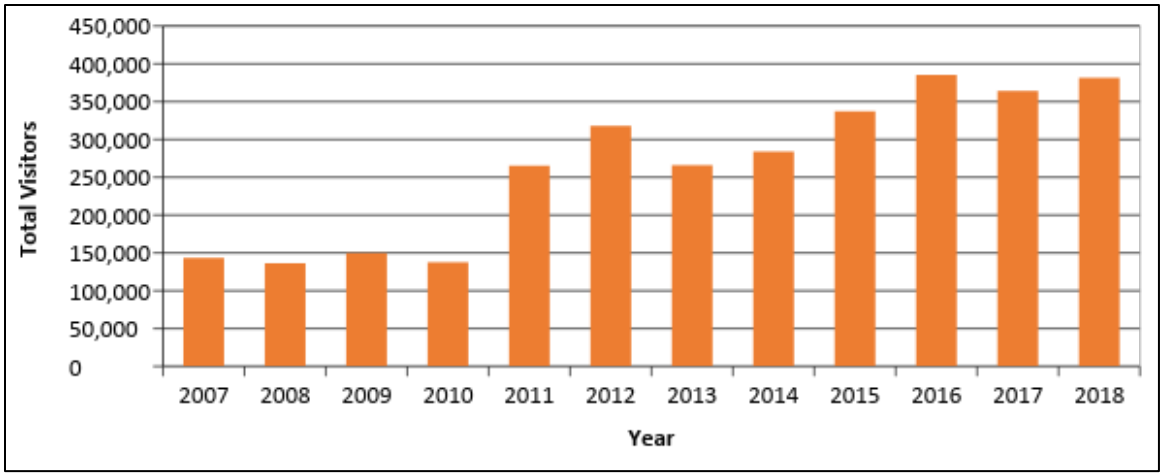


Figure 2-5. Visitation to Flight 93 National Memorial by year, 2007 through 2018 (NPS-IRMA 2019). An increase in visitation occurred in 2011 and corresponds to the completion of the permanent memorial.

Natural Resources

Landscape Ecological Setting

FLNI is found within the Central Appalachian ecoregion (EPA, Level 3; Figure 2-6). In Pennsylvania, this ecoregion is characterized by high elevation plateau (EPA 2013). Bedrock material is often comprised of sandstone or shale (EPA 2013). In Pennsylvania, which constitutes the northernmost reaches of the Central Appalachians, forests can vary considerably in their floral and faunal diversity. Dry, species-poor plant communities dominate most ridgetops, with richer, mesic forests being more common along low slopes or valley-bottoms. Habitat quality varies considerably within the ecoregion and is consistent with historic and contemporary patterns of disturbance. Public lands contain the majority of undisturbed (or less recently disturbed) habitats within the ecoregion.

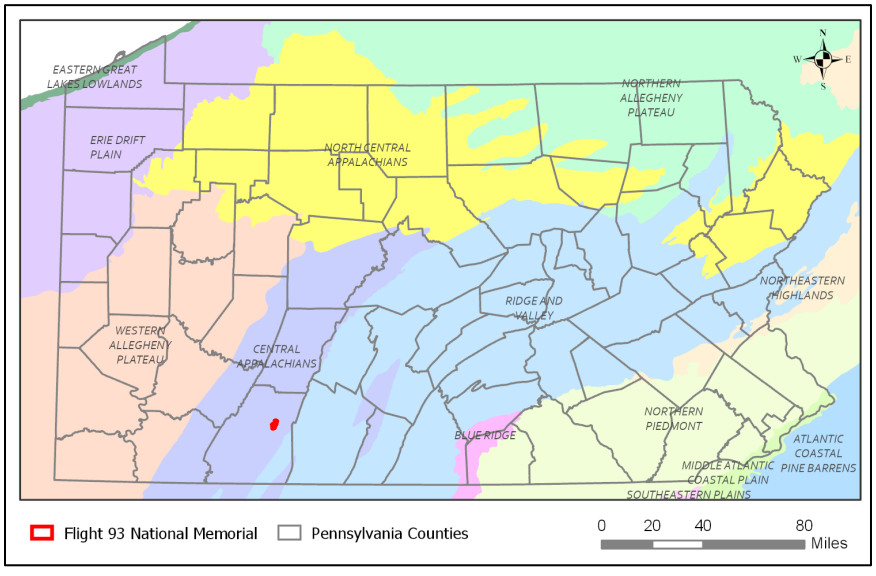


Figure 2-6. Ecoregions (EPA Level 3) of Pennsylvania; Flight 93 National Memorial occurs in the Central Appalachians ecoregion.

FLNI is located within the Stonycreek Watershed (Figure 2-7). The Stonycreek River flows north for 46 miles and ends in Johnstown, PA (Cambria County), where it joins the Conemaugh River. National land cover data (NLCD 2011) indicates that much of the watershed is forested, with significant disturbance from agriculture in the south, and development in the northern reaches of the watershed (Figure 2-8). The Stonycreek watershed has a long history of pollution from acid mine drainage (AMD), a direct result of the local coal mining industry. The elevation of FLNI ranges from about 2,300 – 2,500 feet. Similar to other reclaimed mine sites (areas that had been previously mined and have now been restored to a more natural or economically usable state) in the region, FLNI has a relatively flat aspect. Two tributaries to the Stonycreek River pass through FLNI (Figure 2-9): Grove Run and Lamberts Run. Grove Run originates to the east of FLNI and flows west as is passes through FLNI. Lamberts Run originates within FLNI and is heavily impacted by AMD. Since 1985, local conservation organizations and recreation enthusiasts have been working to restore water quality to the Stonycreek River; this includes AMD treatment at FLNI, where treatment has been active since 1998 (Deal et al. 2008). As a result of historical mining and installation of AMD treatment infrastructure, the Lamberts Run watershed is highly modified (Figure 2-7). These modifications make it difficult to identify the historic flow path of Lamberts Run within FLNI, but the tributary begins to return to a more natural stream setting as it exits FLNI (Figure 2-9).

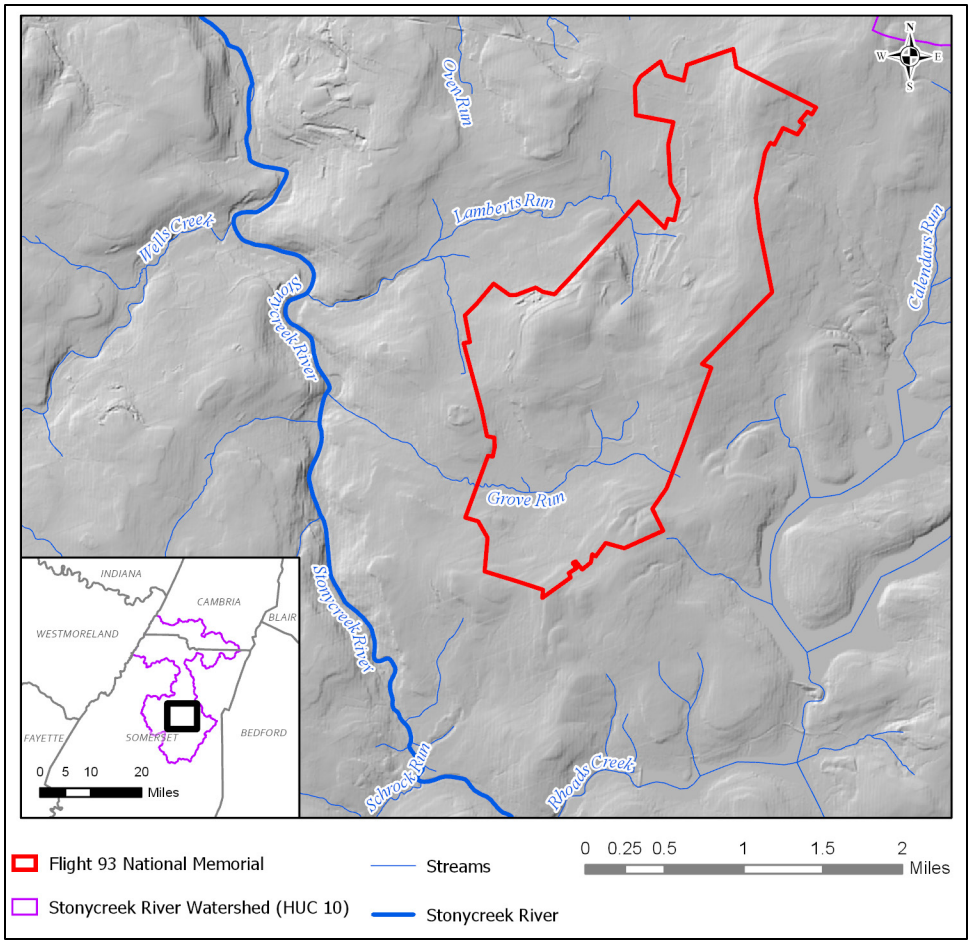


Figure 2-7. Streams associated with Flight 93 National Memorial, located within the Stonycreek River Watershed (HUC 10). Hillshade (10m) has been provided for topographic context.

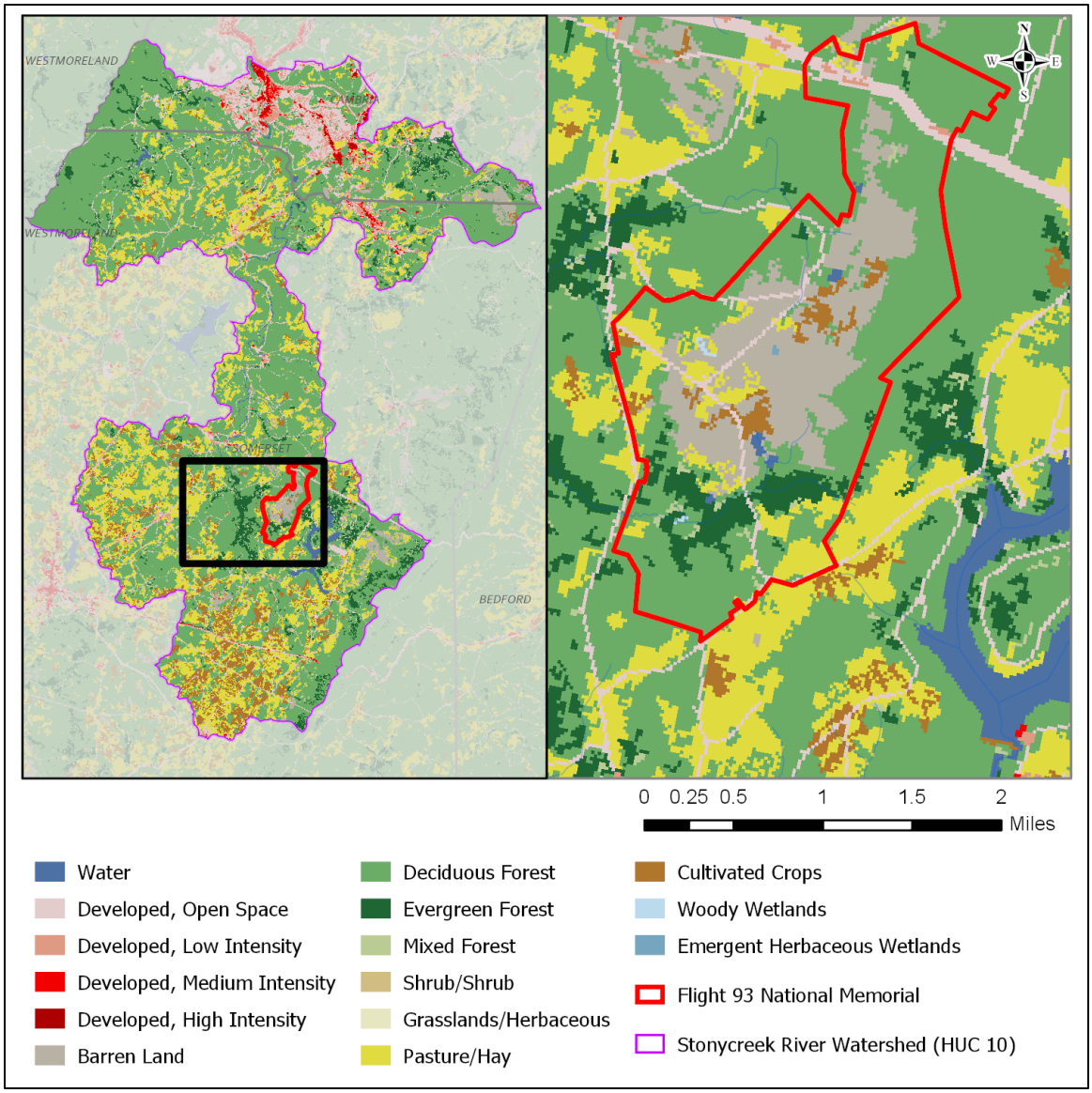


Figure 2-8. Landcover (USGS 2011) within the Stonycreek River Watershed (HUC 10; left) and within Flight 93 National Memorial (right).

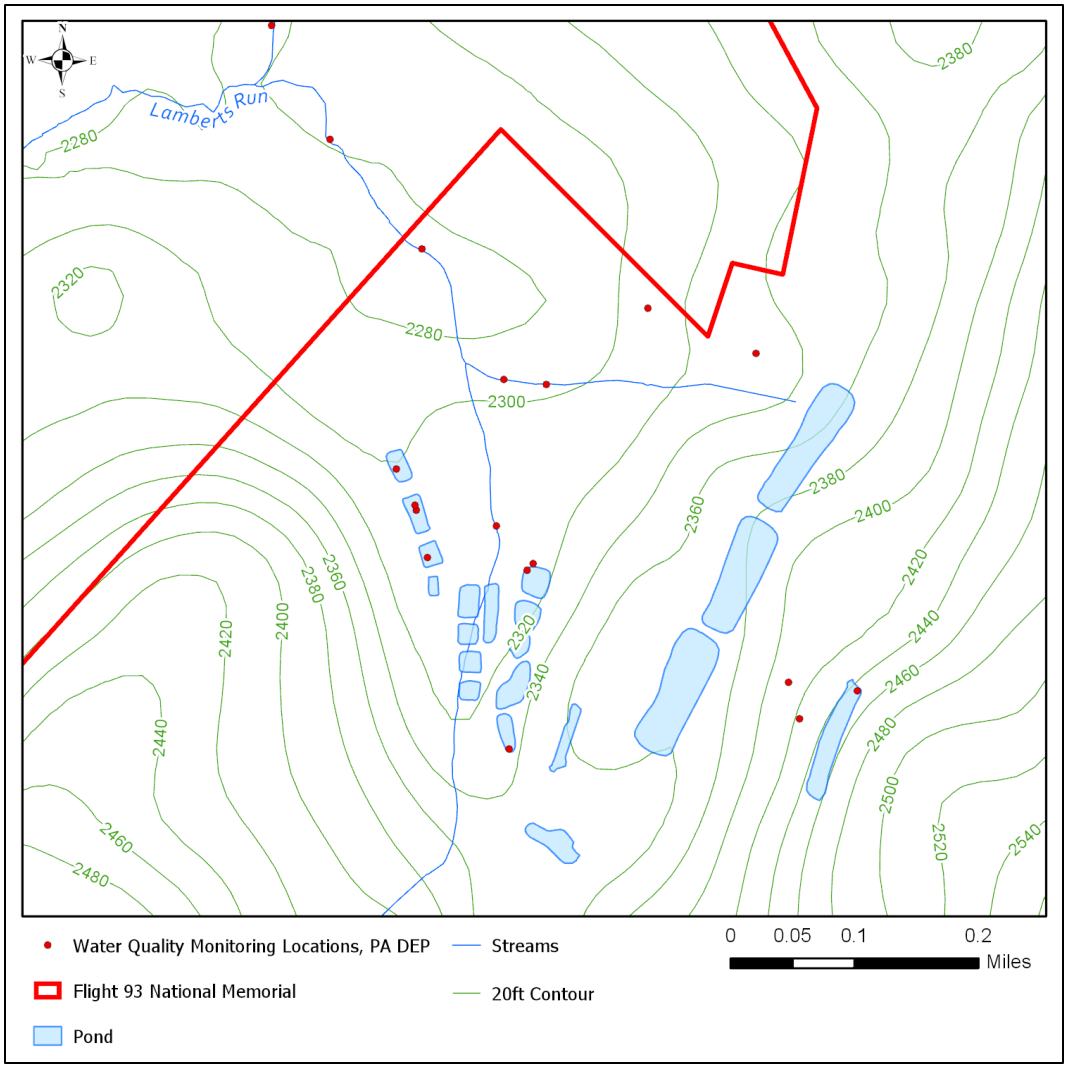


Figure 2-9. Acid mine drainage (AMD) treatment ponds along Lamberts Run at Flight 93 National Memorial. Stream data (blue lines) do not accurately portray flow paths, as infrastructure and grading of the site have altered natural flow patterns the red dots indicate AMD treatment monitoring locations.

Resource Descriptions

Natural communities at FLNI can be classified as several types which include woodlands and forests, early successional grasslands and shrublands, wetlands, and culturally significant features (Figure 2-10). Forests and woodlands are often successional examples of Pennsylvania natural community types (Fike 1999, Zimmerman et al. 2012). However, FLNI contains some mature forest stands that show less evidence of disturbance than one might expect, given the land use history of FLNI. Forest communities represented at FLNI include Red oak – mixed hardwood forests, Black cherry – northern hardwood forests, Northern hardwood forests, Hemlock (white pine) forests, and Hemlock (white pine) – northern hardwood forests, Red maple (terrestrial) forests, and Black locust forests (Fike 1999; see also 4.5.1 Natural Communities). While the majority of forest communities at FLNI are somewhat successional, Red maple (terrestrial) forests and Black locust forests are more disturbed than other forest and woodland communities at FLNI (Figure 2-10).

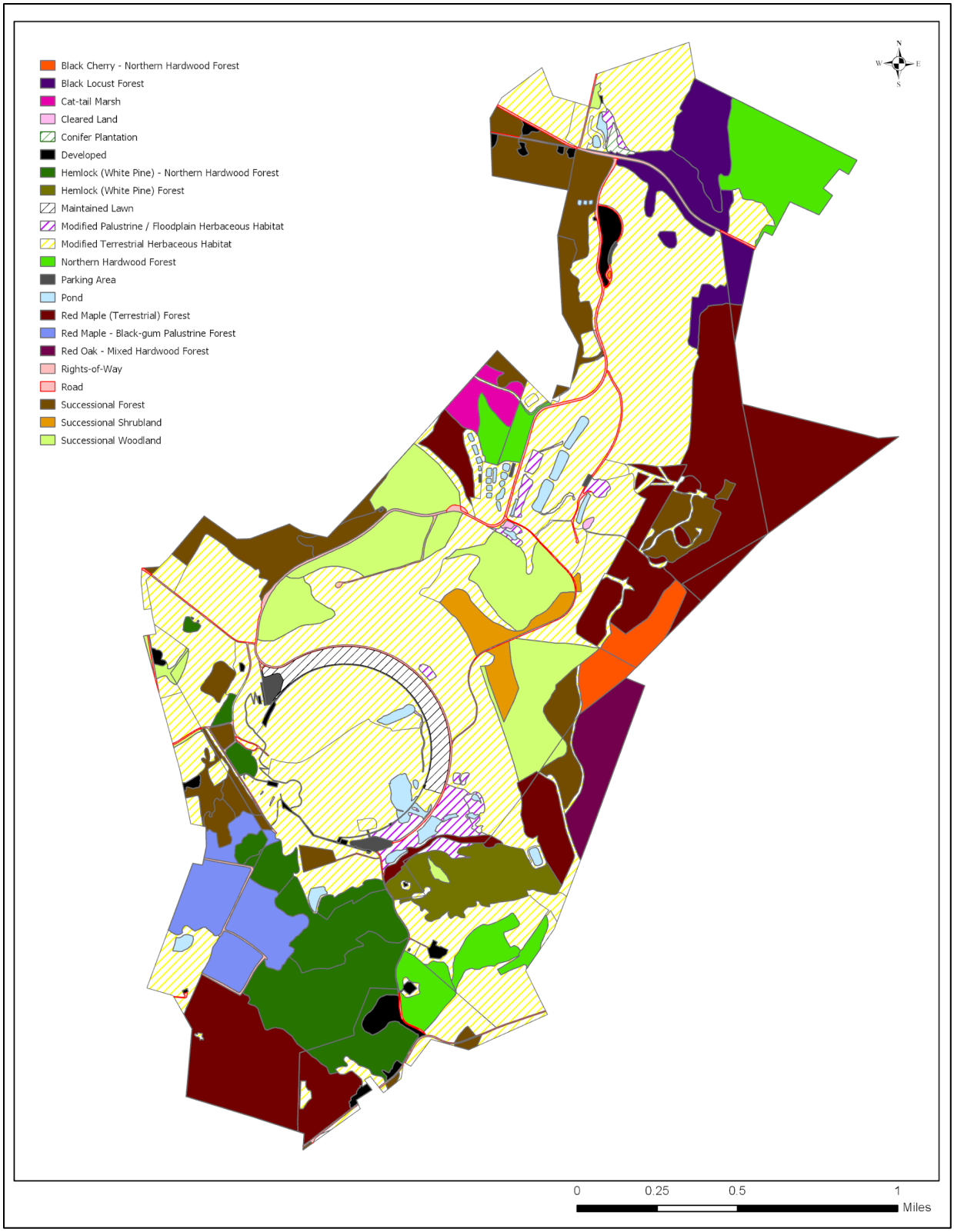


Figure 2-10. Map of natural plant communities, culturally significant features, and infrastructure associated with Flight 93 National Memorial (FLNI) (updated FLNI map from WPC (2005)).

Floral composition in successional communities at FLNI reflect historical disturbance, historical reclamation, and current management at FLNI. Most successional communities at FLNI are the result of traditional surface mine reclamation practices, which include seeding (herbaceous, graminoid species) and/or planting of trees. Based on limited field data and aerial imagery, pitch-pine (*Pinus rigida*), scotch pine (*Pinus sylvestris*), and white pine (*Pinus strobus*) appear to be the most common tree species used in reclamation at FLNI. Ongoing reforestation efforts at FLNI have introduced a greater diversity of tree species, and detailed planting records are available for this work. Since 2012, over 100,000 stems have been planted in a 57-hectare area, which included 34 native species (Tyree et al. 2018; Figure 2-11). There are examples of successional forests and woodlands at FLNI that were probably not planted, which include Red maple (terrestrial) and Black locust forests (Figure 2-10). While red maple and black locust-dominated forests support many native species, these successional forest communities are often invaded by non-native species.

Wetlands at FLNI are often associated with current or former AMD treatment infrastructure, yet several natural wetlands are found within FLNI. Natural wetland communities include Red maple – black gum palustrine forests and Cattail wetlands (Figure 2-10). Most wetlands associated with AMD treatment are located along Lamberts Run. Red maple – black gum palustrine forest is associated with seepage areas or low terraces along Grove Run (Figure 2-10).

Culturally significant features at FLNI are comprised of or embedded within successional communities. Culturally significant features include landscaped features that are actively managed to serve as both a cultural resource and a natural resource and have been established or are maintained to honor the passengers and crew of Flight 93, their families, or other culturally significant conditions at FLNI. These features include natural resource components of the Visitor Center Complex, the Memorial Plaza, and the Tower of Voices (Figure 2-12). The Visitor Center Complex is the central visitation area of FLNI and has several culturally significant features, including the Allée, the Memorial Groves, wildflower meadows near the Visitor Center Complex and the Memorial Plaza, and interpretive trails (Western Overlook Trails). The Allée is a walking path and road that encircles an herbaceous meadow. Along the Allée are the Memorial Groves, comprised of 40 groves of 40 trees that were planted in memorial of the passengers and crew of Flight 93. The Memorial Groves contain eight different species, but mostly consist of maple (*Acer* spp.), oak (*Quercus* spp.) and elm (*Ulmus* spp.). Wildflower meadows consist of open, herbaceous-dominated habitats that were seeded with a native mix of flowering plants and are regularly mowed to maintain open conditions. These meadows support diverse flowering plants and other early successional species, which provide habitat for pollinators, and rare bird species such as the northern harrier (*Circus cyaneus*) and Henslow's sparrow (*Ammodramus henslowii*).

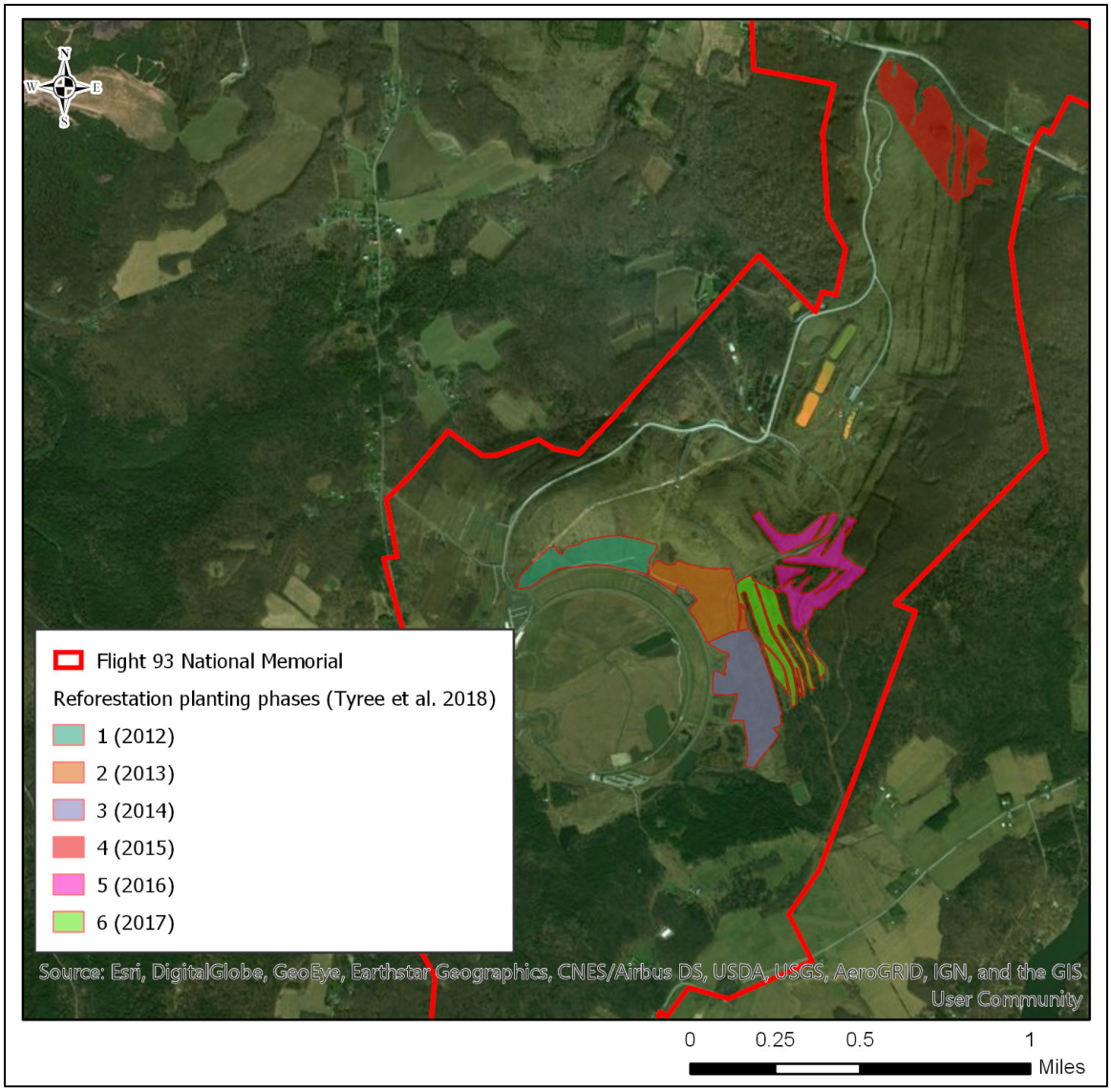


Figure 2-11. Location of reforestation plantings (associated with Tyree et al. 2018) at Flight 93 National Memorial. Spatial data for planting phases provided by Tyree et al. (2018).

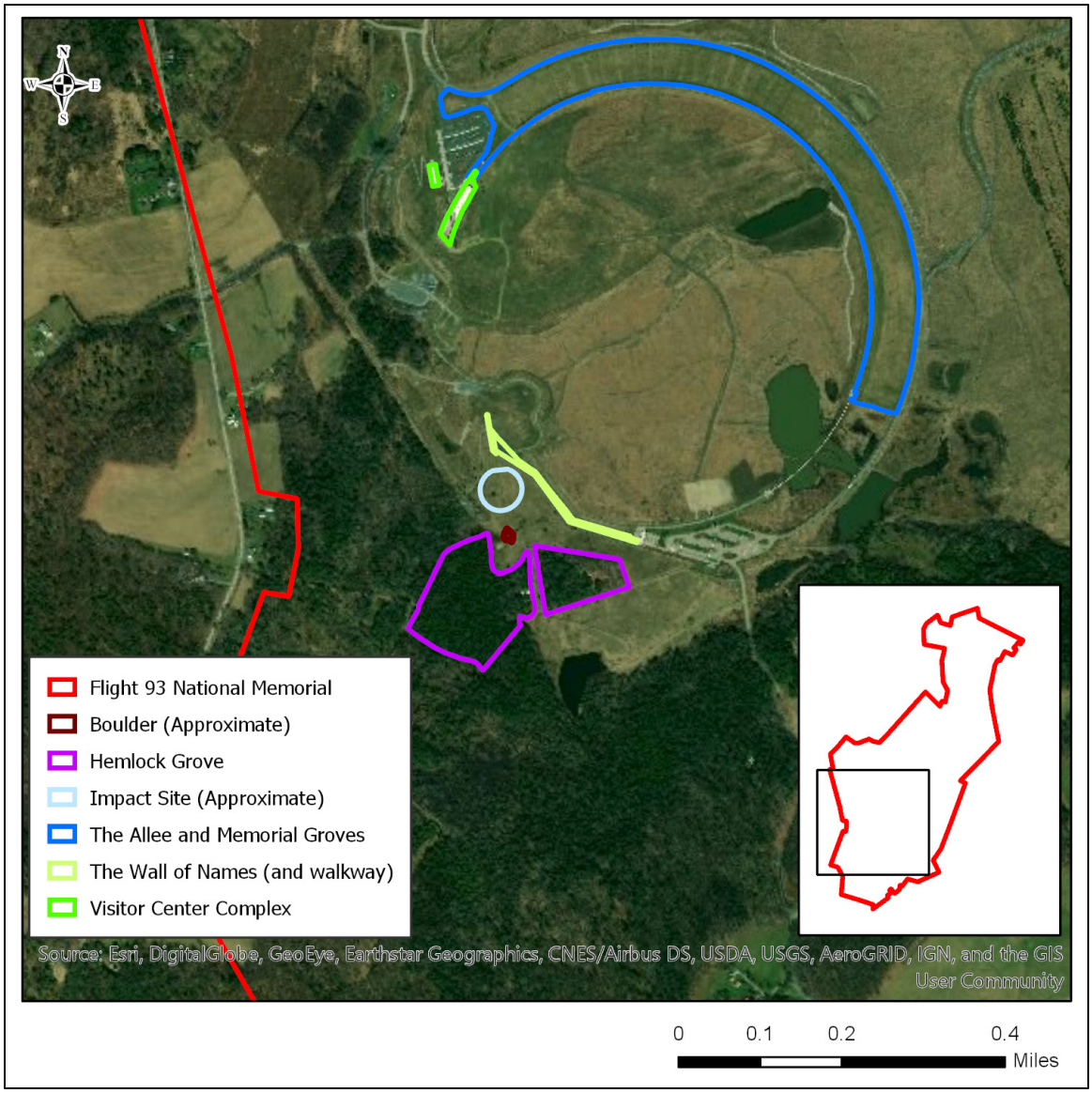


Figure 2-12. Culturally significant features in the southern portion of Flight 93 National Memorial.

The Memorial Plaza is located south of the Visitor Center Complex, and collectively refers to the Wall of Names and the walkway that leads to the Wall of Names. The Memorial Plaza is adjacent to the Impact Site, debris field, and the Hemlock Grove (Figure 2-12). These features provide important viewsheds for visitor experiences at FLNI. The Impact Site often refers to the field between the Memorial Plaza and the Hemlock Grove. A large boulder marks the impact site, and the field surrounding the boulder is actively managed as an herbaceous opening. The Hemlock Grove is found southwest of the Impact Site and represents one of the most important natural communities and culturally significant features at FLNI. The Hemlock Grove is the location where significant remains and personal objects were recovered; visitors are not permitted to enter the Hemlock Grove. The Hemlock Grove is an excellent regional example of Hemlock (white pine) – mixed hardwood forest and is the only culturally significant feature at FLNI that is comprised of mature forest. This feature

is also one of the most heavily managed natural resources within FLNI, as hemlock (*Tsuga canadensis*) trees are aggressively treated for hemlock wooly adelgid (*Adelges tsugae*) (HWA) (Turcotte et al. 2012) (see Section 2.2.3. for more information about HWA). The Tower of Voices is located north of the Visitor Center Complex (Figure 2-13) and consists of a 93-foot tower which, when completed, will feature 40 wind chimes. The Tower of Voices serves as a visual and audible reminder of the passengers and crew of Flight 93. Some landscaped, natural features have been established at this site, and additional native species will be introduced near the Tower of Voices to support pollinators (Figure 2-13).

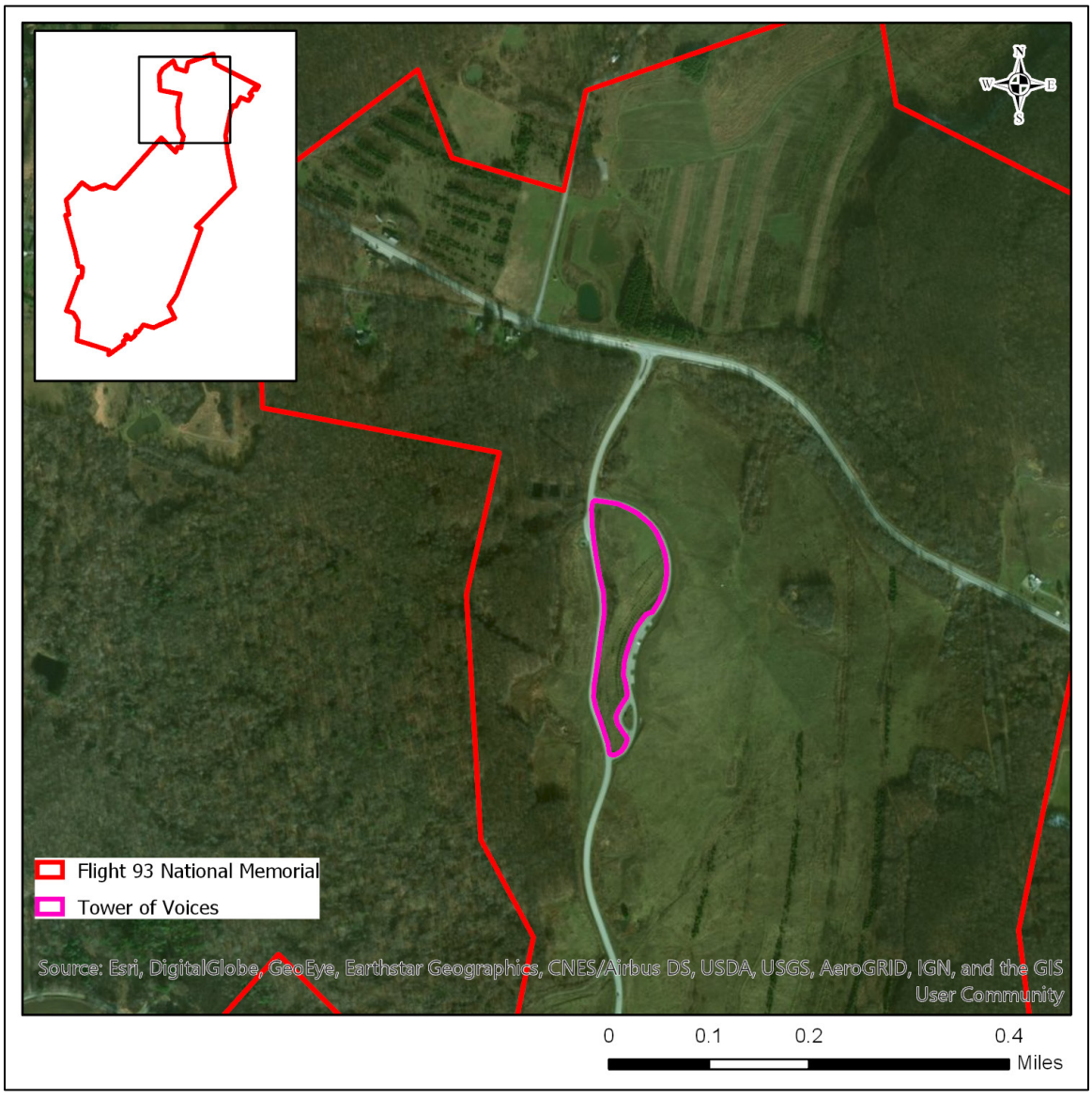


Figure 2-13. The location of the Tower of Voices, a culturally significant feature in the northern portion of Flight 93 National Memorial. Aerial photography was collected prior to the construction of the Tower of Voices.

Resource Issues Overview

In the FLNI NRCA, stressors are defined as biotic or abiotic factors that are *currently* impacting natural resource conditions. Biotic and abiotic factors that can *potentially* impact natural resource conditions are classified as threats. This distinction may be useful for FLNI staff when developing research, monitoring, or management goals for natural resources at FLNI. Historical disturbances (e.g. mining and reclamation) within FLNI have resulted in stressors and threats that include invasive species, soil compaction, and acid mine drainage (AMD) pollution. However, no data have been collected at FLNI to document the impact of landscape-level or global processes (e.g. wet deposition and climate change) on natural resources at FLNI. Several pervasive stressors and threats are discussed in this section, but detailed, resource-specific discussions of stressors and threats can be found in Chapter 4.

Invasive species were defined in Executive Order 13112 (1999) as "a species that is non-native to the ecosystem under consideration and whose introduction causes or is likely to cause economic or environmental harm or harm to human health". At FLNI, there are both invasive plant and insect species that pose a significant stress and threat to ecological quality. Common invasive plants at FLNI include autumn olive (*Elaeagnus umbellata*), spotted knapweed (*Centaurea stoebe*), and bull thistle (*Cirsium vulgare*). Most of these invasives are found along roadsides, in powerline cuts, and in the reclaimed strip mine areas at FLNI. Invasive species control and eradication often receive significant attention in resource management.

An invasive insect of immediate concern at FLNI is the hemlock woolly adelgid (HWA) (*Adelges tsugae*). HWA is an aphid-like insect that attacks and eventually kills hemlocks (*Tsuga canadensis*). It is a stressor to all hemlock-dominated communities at FLNI, especially the Hemlock Grove (a culturally significant feature). HWA has the potential to significantly alter forest composition at FLNI by killing hemlock and is a prime example of a stressor of natural and culturally significant features at FLNI. While hemlock trees are in several areas at FLNI, HWA has only received management attention in the Hemlock Grove.

Native wildlife species can also act as threats and stressors at FLNI. White-tailed deer (*Odocoileus virginianus*) are a threat to ecological quality at FLNI, as overbrowsing has the potential to impact species composition in natural communities throughout FLNI. Canada geese (*Branta canadensis*) are a stressor to the visitor experience and were identified by FLNI staff as a management concern at the Memorial. More specifically, excessive feces from geese can degrade visitor experience in several areas, include the Allee, the Wall of Names, and the walkway to the Wall of Names. While Canada geese have been identified by FLNI as a stressor for some of the culturally significant features, there is no evidence that Canada geese are a stressor or threat to natural resources at FLNI.

In the absence of a well-functioning AMD treatment system, AMD would be a major stressor of stream water quality at Lamberts Run and Stonycreek River via Lamberts Run. Water quality monitoring data from Lamberts Run, and from drainages associated with AMD treatment systems at FLNI, indicate drastic improvements in water quality as it leaves FLNI. However, AMD still impacts the Stonycreek River. Additional sources of AMD along Lamberts Run have been documented outside of FLNI, and treatment for these sources of pollution is ongoing. Water quality in the

Stonycreek River, sampled upstream and downstream of the river's convergence point with Lamberts run, demonstrated a negative impact of AMD on stream biota. Lower macroinvertebrate diversity was documented downstream of the convergence point, and this effect continued for three miles downstream.

Climate change also poses a significant threat to ecological quality. Gonzales et al., (2018) used historic data to analyze trends of precipitation and temperature across all 417 US national parks, and to model future potential temperature and precipitation conditions for these sites. However, climate change related effects, such as increased precipitation, increased temperature, frequency of storm events, or species range shifts, were not considered in the resource condition assessments for this NRCA. Instead, the hypothetical impact of climate change on relevant natural resources is addressed in Chapter 4. Monitoring the potential impacts of climate change for any resources at FLNI will require a detailed monitoring protocol that is specific to each resource and potential monitoring targets and highlighted in Chapter 5.

Resource Stewardship

FLNI staff provided a list of suggested topics included in this NRCA (Table 2-2). The Western Pennsylvania Conservancy (WPC) staff categorized these topics as resources, indicators, threats, or stressors. All topics presented by FLNI staff were incorporated into the NRCA, and chapter locations (chapter, section, and/or subsection) have been referenced in Table 2-2. A compressive list of natural resources included in the NRCA is provided in Chapter 3 (3.2.2. NRCA Framework).

Table 2-2. Natural Resource Condition Assessment (NRCA) topics provided by Flight 93 National Memorial (FLNI) staff at the November 2017 project kick-off meeting.

Suggest NRCA Topic (from FLNI)	Classification of Resource for NRCA	Management Concern	Classification of Management Concern	Relevant NRCA Chapter
Natural communities	Ecological Quality - Natural Communities	Wildlife management, white-tailed deer	Stressor	Chapter 4 (4.5.1 Natural Communities)
Reforestation areas	Ecological Quality - Natural Communities	None	Improvement activity	Chapter 2 (2.2.2. Natural Resources, Local Ecological Setting)
Wetlands	Ecological Quality - Natural Communities	Invasive plants, acid mine drainage	Stressor	Chapter 4 (4.5.1 Natural Communities)
Allee trees	Ecological Quality - Culturally Significant Features	Loss and replacement of trees	Threat	Chapter 4 (4.5.2. Culturally Significant Features)
Culturally significant features (all)	Ecological Quality - Culturally Significant Features	Wildlife management, Canada geese	Stressor	Chapter 4 (4.5.2. Culturally Significant Features)

Table 2-2 (continued). Natural Resource Condition Assessment (NRCA) topics provided by Flight 93 National Memorial (FLNI) staff at the November 2017 project kick-off meeting.

Suggest NRCA Topic (from FLNI)	Classification of Resource for NRCA	Management Concern	Classification of Management Concern	Relevant NRCA Chapter
Crash site	Ecological Quality - Culturally Significant Features	Mowing regime	Stressor	Chapter 4 (4.5.2 Ecological Quality)
Hemlock grove	Ecological Quality - Culturally Significant Features	hemlock wooly adelgid (HWA)	Stressor	Chapter 4 (4.5.2 Ecological Quality)
Memorial groves	Ecological Quality - Culturally Significant Features	Loss and replacement of trees	Stressor	Chapter 4 (4.5.2. Culturally Significant Features)
Memorial Plaza	Ecological Quality – Culturally Significant Features	Invasive plants	Stressor	Chapter 4 (4.5.2. Culturally Significant Features
Tower of Voices, pollinator garden	Ecological Quality - Culturally Significant Features	None	Improvement activity	Chapter 4 (4.5.2. Culturally Significant Features)
Acid mine drainage ponds	Stream Water Quality - Water Chemistry	Acid mine drainage	Stressor	Chapter 4 (4.3. Stream Water Quality)

Air quality receives significant attention in NRCAs across the National Park system. Indicators of air quality are also tied to other natural resource conditions, such as stream water, biological, and ecological quality. Certain air quality indicators (ozone, visibility, acid deposition, and wet deposition of mercury) can directly impact human health and/or visitor experience and natural and cultural resources, which emphasizes their need for inclusion in the FLNI NRCA. Night sky (dark skies) and ambient noise conditions are also included in most NRCAs. FLNI attempts to provide a tranquil environment for visitors, and certainly this value is related to visual and auditory conditions associated with night sky and acoustic quality. Threats and stressors to acoustic quality are associated with the landscape surrounding FLNI (noise from roadways, recreational boating, etc.), and have the potential to degrade visitor experience. While night time programming is currently uncommon at FLNI, dark skies can be associated with tranquility, and offer an opportunity to enhance visitor experience during future programs. Dark sky conditions may be tied to a number of biological resources that utilize the park on a permanent or temporary basis (e.g. invertebrates, insects, birds, mammals).

Stream water quality is associated with aquatic and terrestrial ecosystems at FLNI. The AMD that impacts Lamberts Run, and the treatment infrastructure associated with AMD, predate the establishment of FLNI. AMD treatment has been ongoing since 1998 (Deal et al. 2008) and will continue to be a management priority for partner organizations at FLNI.

The condition of natural communities and culturally significant features at FLNI are indicators of ecological quality in the NRCA. Stressors that impact plant community composition could have a detrimental cascade effect on the fauna of FLNI. Invertebrates, birds, mammals, or herpetofauna that depend on specific ecological conditions could be negatively impacted by small changes to local ecology. Ecological quality could also be degraded by active management for AMD. AMD in Lamberts Run has required the modification of local topography, natural flow paths, and has required the installation of AMD treatment infrastructure which includes treatment/sedimentation ponds, roads, culverts, and parking lots. While necessary to improve stream quality, AMD infrastructure could serve as a dispersal corridor for invasive plant species which in turn, reduces ecological quality of nearby wetland and upland habitats.

Management Directive and Planning Guidance

A number of culturally significant features have received management attention at FLNI, and FLNI has identified a number of management challenges associated with these features. Wildflower meadows near the Visitor Center Complex have been mowed to maintain open, early successional conditions. Frequency and seasonality of mowing are important considerations for maintaining plant species diversity in these meadows, and mowing frequency and timing of mowing can negatively impact plant and/or pollinator diversity. Lack of appropriate BMPs for mowing in planted wildflower meadows have been identified as a management challenge at FLNI. FLNI staff has also identified the Hemlock Grove as a management challenge. Conserving hemlock at this site is a major goal for FLNI given the threat of hemlock wooly adelgid (HWA). NPS partners (US Forest Service) have provided treatment, monitoring, and management guidance for HWA (see Turcotte et al. 2012). In addition to treating HWA, there are other forest management activities that could improve conservation success for hemlock at this site, including thinning of the canopy to release understory hemlock, planting naturally-HWA-resistant hemlock trees, or treatment of invasive species like Japanese stiltgrass (*Microstegium vimineum*) to improve hemlock recruitment.

Status of Supporting Science

The status of supporting science for FLNI and relevant authors are provided in Table 2-3. FLNI is a relatively new NPS site and was established after the inception of the NPS Inventory and Monitoring Program's Eastern Rivers and Mountains Network (ERMN). As a result, FLNI does not have formal initial baseline inventories. The ERMN also does not currently implement any long-term natural resource monitoring efforts at FLNI. As such, field-collected data for natural resources at FLNI are rare and were usually associated with specific targets of academic research. Stream water quality data for Lamberts Run are available for FLNI, as AMD systems have required routine monitoring since active treatment began in 1998. A number of datasets used to score resource conditions were derived for FLNI using spatial interpolation (Table 2-3), and the results of these spatial analyses were provided by the NPS Air Resources Division (NPS ARD) and the NPS Natural Sounds and Night Skies Division (NPS NSNSD).

Table 2-3. Status of supporting science for relevant natural resources at Flight 93 National Memorial (as of February 2019).

Resource	Indicator in NRCA	Period of Available Data	Data type	Source
Air Quality	Wet deposition (nitrogen, sulfur), ozone, visibility	2017	Spatial interpolation	Taylor 2017; National Park Service Air Resources Division website
	Wet deposition (mercury)	2011–2015	Spatial interpolation	National Park Service Air Resources Division website
Biological Quality	Mammals (Bats)	2015	Field collected	Nagle and Gates 2018
	Birds	2018	Field collected	eBird 2017; Yeany 2019
	Pollinators (Bees)	2016–2017	Field collected	Oliver 2017; Kautz et al. 2018
Night Sky and Acoustic Quality	Soundscapes	2016	Field Collected	Arup North America Ltd 2017
	Soundscapes	2014	Spatial interpolation	National Park Service Natural Sounds and Night Skies Division website
	Night Skies	2013	Spatial interpolation	Moore et al. 2013
Stream water quality	Water chemistry	2001–2009	Field collected	Pennsylvania Department of Environmental Protection 2018; Somerset County Conservation District 2018
Ecological Quality	Natural Communities	2005–2017	Field collected	Western Pennsylvania Conservancy 2005; Turcottee et al. 2012; Marconi and Knee 2013; Tyree et al. 2015; Oliver 2017; Tyree et al. 2018
	Natural Communities	2005, 2018	Field collected, remote sensing	WPC 2005; 2018 fieldwork done by the Western Pennsylvania Conservancy

Study Scoping and Design

Preliminary Scoping

Park and Stakeholder Involvement

A kickoff meeting for the FLNI NRCA was held on November 2, 2017 in Somerset, PA. Meeting participants included staff from FLNI: Mary Jane Hartman, Mary Ellen Snyder, and Dan Albus. Other participants (in person or via conference call) from stakeholder organizations included Christine Arnott, Holly Salazer, Marian Norris, Sheila Colwell, Pete Sharpe, and Amanda Babson (NPS-NERO), Adam Hnatkovich, Mary Ann Furedi, and Ephraim Zimmerman from the Western Pennsylvania Conservancy (WPC), Matt Marshall, Caleb Tzilkowski, and Stephanie Perles (NPS-ERMN), Danny Filer (NPS), and Karen Sykes (USFS). FLNI staff presented a preliminary list of resources to stakeholders (Table 2-2; Chapter 2, Section 2.3. Resource Stewardship). The WPC provided information on previous work conducted at FLNI and discussed their proposed approach to the FLNI NRCA. The meeting also included a field visit to FLNI. Coordination with stakeholders continued over the life of the project with WPC hosting quarterly WebEx meetings and conference calls. During these meetings, stakeholders decided on a list of natural resources to be analyzed in the NRCA, discussed methods for scoring condition of natural resources, and determined procedures for NRCA document review.

Study Design

General Approach and Methods

The FLNI NRCA was organized according to resources identified through stakeholder meetings. The following definitions describe the hierarchy of the FLNI NRCA.

- **Resource**: Resources considered in this NRCA include **Air Quality, Night Sky and Acoustic Quality, Stream Water Quality, Biological Quality, and Ecological Quality.** Resources are groups of indicators and form the primary reporting areas in Sections 4 and 5 of the NRCA.

- **Indicators**: Resources required multiple indicators and/or metrics to develop a comprehensive profile of resource condition.

- **Metric**: Metrics are quantitative or qualitative data for which resource condition, trend, and data confidence are scored for a specific indicator within a specific resource category. Just like a resource can have multiple indicators, and indicator can have multiple metrics.

Each resource reporting section (Section 4) contains the following sub-sections that provide detail on the resource, the types of indicators and metrics that were used to report resource condition, and trends for FLNI.

- ***Indicator Description***: This section provides an overview of each indicator. Relevant literature is introduced in this section.

- ***Threats and Stressors*** are also introduced in this section. Multiple indicators (and resources) may share threats or stressors. In these circumstances, threats and stressors have been discussed separately for each indicator.

- ***Data and Methods***: Each indicator has at least one metric used to score condition, trend, and confidence in data. Methods of calculation for each metric are summarized and relevant sources are cited.

- ***Reference Conditions***: This section addresses the reference conditions used to score each indicator and includes a brief discussion of relevant literature (if available). Reference conditions are defined as the criteria used to score each metric (Table 3-1).

- ***Condition and Trend***: This subsection contains a description of resource condition and trend for each metric. Scoring is based on reference conditions identified in the previous subsection (Tables 4-5). This section contains the condition assessment table for each metric used in the NRCA, which represents the composite score for that metric.

- ***Levels of Confidence and Data Gaps***: This section contains justification for confidence scores that are applied to each metric (Tables 3-1 and 3-2). Data derived from spatial interpolation were scored as medium confidence. This method is consistent with previously published NRCA reports, and guidance from NPS staff and project stakeholders.

Table 3-1. Symbols used to indicate condition, trend, and confidence in data used for the Flight 93 National Memorial Natural Resource Condition Assessment.

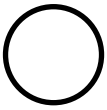
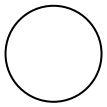
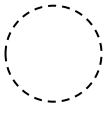
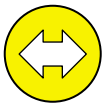
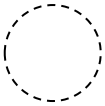
Condition Status		Trend in Condition		Confidence in Assessment	
Condition Icon	**Condition Icon Definition**	**Trend Icon**	**Trend Icon Definition**	**Confidence Icon**	**Confidence Icon Definition**
	Resource is in Good Condition		Condition is Improving		High
	Resource warrants Moderate Concern		Condition is Unchanging		Medium
	Resource warrants Significant Concern		Condition is Deteriorating		Low

Table 3-2. Example of interpretation of condition symbols used in the Flight 93 National Memorial Natural Resource Condition Assessment.

Symbol Example	Description of Symbol
	Resource is in good condition; its condition is improving; high confidence in the assessment.
	Condition of resource warrants moderate concern; condition is unchanging; medium confidence in the assessment.
	Condition of resource warrants significant concern; trend in condition is unknown or not applicable; low confidence in the assessment.
	Current condition is unknown or indeterminate due to inadequate data, lack of reference value(s) for comparative purposes, and/or insufficient expert knowledge to reach a more specific condition determination; trend in condition is unknown or not applicable; low confidence in the assessment.

NRCA Framework

The FLNI NRCA framework was vetted with project stakeholders (Table 3-3). Resources considered in this NRCA reflect the values of FLNI along with a suite of resources, indicators, and metrics with an established presence in previously published NRCA reports (Air Quality and Night Sky and Acoustic Quality indicators and metrics). NRCA reports for NPS sites located in western Pennsylvania (Allegheny Portage Railroad National Historic Site (ALPO) and Johnstown Flood National Memorial (JOFL)), and additional NPS sites with heavy management emphasis towards a historical or cultural reference condition (Gettysburg National Military Park (GETT) and Eisenhower National Historic Site (EISE)), were used as examples for writing this NRCA since they share similar cultural and natural resources.

Table 3-3. Natural Resource Condition Assessment framework for Flight 93 National Memorial.

Resource	Indicators	Metric(s)
Air Quality	Ozone	• Human Health: Annual 4th-highest 8hr concentration • Vegetation Health: 3-month maximum 12hr W126
	Visibility	• Haze index
	Wet Deposition	• Nitrogen • Sulfur • Mercury
Night Sky and Acoustic Quality	Night Sky	• Ambient light reading (ALR)
	Soundscapes	• L50 DBA impact

Table 3-3 (continued). Natural Resource Condition Assessment framework for Flight 93 National Memorial.

Resource	Indicators	Metric(s)
Stream Water Quality	Water Chemistry	• pH • Alkalinity • Iron • Aluminum
	Aquatic Macroinvertebrates	• No data available
Biological Quality	Birds	• Grassland bird point counts • Grassland bird habitat
	Pollinators	• Relative species composition
	Mammals	• No metric available
	Herpetofauna and Fish	• No data available
Ecological Quality	Natural Communities	• Natural community mapping
	Culturally Significant Communities	• Hemlock Grove • Tower of Voices, Pollinator Garden • Memorial Groves • Memorial Plaza • Wildflower meadows

Natural Resource Conditions

Air Quality

Air Quality – Ozone

Based on multiple metrics, ozone conditions at FLNI warrant moderate concern. Metrics for ground-level ozone were estimated at FLNI using spatial interpolation methods, which reduces confidence in these estimates. Trend data are no available for ozone metrics. On-site monitoring stations would improve estimates of ground-level ozone at FLNI.

Indicator Description

Ground-level ozone is created by the reaction of nitrogen oxides (NOx) and volatile organic compounds in the presence of sunlight (EPA 2018a). Volatile organic carbons (VOCs), including hydrocarbons, often enter the atmosphere through fossil fuel combustion, and evaporation of liquid fuels or other organic compounds (NASA 2003). The chemical reaction that produces ground-level ozone occurs in the presence of sunlight and heat, and therefore, unhealthy levels of ozone are more likely to occur on sunny days during warmer times of the year (EPA 2018a). Nitrogen oxides and VOCs are both released from fossil fuel combustion; ozone-formation can occur more frequently in urban environments where vehicle density is high, or where industrial fossil fuel emissions are high. Rural areas, such as FLNI, can also experience high levels of ozone, despite the lower vehicle density of urban areas. Ozone is easily transported by wind (EPA 2018a), and emissions from local electrical generators or industrial operations (both involving fossil fuel combustion) could drive an increase in ground-level ozone production in less densely populated areas. Ground-level ozone can impact a large segment of the human population, including people who regularly do physical exertion outdoors (recreation or physical labor), people who are sick, children, and the elderly (EPA 2018a). Ozone can make it difficult to breathe deeply, can irritate the throat and/or damage airways, or cause respiratory conditions like chronic obstructive pulmonary disease. Ground-level ozone impacts are exacerbated by medical conditions such as asthma, emphysema, or bronchitis (EPA 2018b).

At FLNI, ground-level ozone has the potential to negatively impact visitor experience. Most high-density visitation areas at FLNI are outdoors and require movement between parking areas and monuments. Similarly, trails provide opportunity for hiking and biking throughout FLNI. Any outdoor experience at FLNI could result in physical exertion. While ozone pollution has the potential to impact all visitors, those visitors with health conditions that are exacerbated by ground-level ozone exposure could be heavily impacted by ozone pollution. Ground-level ozone can also negatively impact sensitive plant species by reducing photosynthesis and plant growth. When combined with other stressors of plant health, such as tissue damage from insects, ice, snow, fire, and wind damage, ground-level ozone may increase plant susceptibility to disease (EPA 2017a). Susceptible species at FLNI include black cherry (*Prunus serotina*), quaking aspen (*Populus tremuloides*), white pine (*Pinus strobus*), and tuliptree (*Liriodendron tulipifera*) (EPA 2017a).

Data and Methods

Ground-level ozone estimates for FLNI are derived from the EPA Air Quality System database (AQS). NPS commonly calculates ozone metrics using two methods, and each metric serves as an

indicator for air quality condition for human health or plant health: 4th highest daily max 8-hour average ozone concentration (human health), and 3-month maximum 12-hour W126 (plant health) (Taylor 2017, see Appendix C for methods for calculating metrics). Ideally, data for scoring ozone condition at NPS sites would be collected on-site, however, FLNI does not have on-site monitoring. Fortunately, the National Park Service Air Resources Division (NPS-ARD) has created a spatial dataset that provides estimates of ground-level ozone for NPS sites without on-site monitoring (Taylor 2017, see Appendix A for geospatial estimation methods). The 4th highest daily max 8-hour average ozone concentration and 3-month maximum 12-hour W126 metrics were averaged over a 5-year period, and the results were extrapolated across geographic space using Inverse Weight Distance (IDW) (Taylor 2017, see Appendix A for geospatial estimation methods). As noted in Taylor (2017), there is uncertainty in estimates using this spatial interpolation technique.

Reference Conditions

- As an air quality indicator for human health, ground-level ozone was scored in good condition if the estimated annual 4th-highest daily maximum 8-hour average was less than or equal to 60 parts per billion (ppb); values between 61–75ppb warranted moderate concern, and values equal to or greater than 76ppb warranted significant concern.

- As an air quality indicator for plant health, ground-level ozone was scored in good condition if the estimated W126 level were less than 7 parts per million hours (ppm-hrs); W126 levels between 7 and 13 ppm-hrs warranted moderate concern, while values greater than 13 ppm-hrs warranted significant concern.

Condition and Trend

NPS-ARD interpolation of Annual 4th-highest 8-hour concentration resulted in a value of 68.4ppb (Table 4-1). Based on NPS-ARD benchmarks, this metric suggests moderate concern for ground-level ozone at FLNI. Similarly, NPS-ARD estimates of W126 resulted in a value of 8.7 ppm-hrs; based on NPS-ARD benchmarks, this metric suggests moderate concern for ground-level ozone at FLNI.

No trend information is available for FLNI. Because of the time of establishment of FLNI, there are no interpolated data available from previous sampling or modeling periods that provide ozone trend metric estimates for FLNI (Table 4-1).

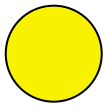
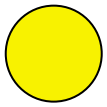
Level of Confidence and Data Gaps

The level of confidence for ground-level ozone condition metrics at FLNI is medium. There are no on-site monitoring stations at FLNI, and ozone metrics were obtained from spatial interpolation methods using data from off-site monitors.

Source(s) of Expertise

- Data for the NRCA were supplied by NPS-ARD (Taylor 2017). Guidance for interpretation and inclusion in the NRCA were provided by Holly Salazer at NPS-NERO. Detailed methods can be found in the National Park Service Air Quality Analysis Methods (Taylor 2017).

Table 4-1. Condition, trend, and confidence scores for ozone, an indicator of air quality in the Flight 93 National Memorial (FLNI) Natural Resource Condition Assessment (NRCA). Data supplied by the National Park Service Air Resources Division (NPS-ARD) (2018) and methods of scoring follow Taylor (2017).

Indicator	Metric	Status and Trend	Rationale and Reference Conditions
Ozone	Human health: Annual 4th-highest 8hr concentration		• **Condition**: Human health risk from ground-level ozone warrants moderate concern at FLNI. Based on NPS-ARD benchmarks and the 2011–2015 estimated ozone of 68.4ppb. • **Trend**: No trend information is available. • **Confidence**: Medium; estimates are based on interpolated data from more distant ozone monitors.
	Vegetation health: 3-month maximum 12hr W126		• **Condition**: Vegetation health risk from ground-level ozone warrants moderate concern at FLNI. Based on NPS-ARD benchmarks and the 2011–2015 estimated W126 metric of 8.7ppm-hrs. • **Trend**: No trend information is available. • **Confidence**: Medium; estimates are based on interpolated data from more distant ozone monitors.

Air Quality - Visibility

Estimates of the haze index suggest a significant concern for visibility at FLNI. However, trend analysis suggests that visibility conditions are improving. The haze index was calculated from data collected at FLNI or a nearby sampling location, and these data have a rating of high confidence. Similar scores for visibility have been reported for other regional NPS sites (Fort Necessity national Battlefield (FONE), Johnstown Flood National Memorial (JOFL), Allegheny Portage Railroad National Historic Site (ALPO), and Friendship Hill National Historic Site (FRHI)).

Resource Description

Visibility can be impacted by particulate matter in the air. Haze is created by the interaction of particulate matter and light, which can absorb or scatter light, resulting in impaired visibility. Clear views contribute significantly to visitor experiences at FLNI. A number of memorial features have been designed to emphasize the viewshed surrounding the flight path of Flight 93, which includes views from the Visitor Center Complex to Memorial Plaza, and from the Memorial Plaza and Wall of Names towards the Impact Site and Hemlock Grove. The open landscape at FLNI lends itself to long-distance views of these memorial features and the surrounding grasslands and forested stands.

Data and Methods

As an indicator of air quality, visibility conditions have the potential to impact visitor experience at FLNI. Visibility is monitored through the IMPROVE (Interagency Monitoring of Protected Visual Environments) network. The IMPROVE network collects particulate samples every three days for a 24-hour period and uses this data to calculate visibility impairment. This is known as the Haze Index, reported in deciviews (dv) (Taylor 2017). The Haze Index can be interpreted as the deviation from

expected visibility (impairment) that results from human activity (Taylor 2017). Mid-range days include those sample days where visibility is between the 40th and 60th percentile (Taylor 2017). Haze index is calculated by subtracting estimated natural visibility condition on mid-range days from the measured visibility on mid-range days (Taylor 2017). Trends are calculated from examining both Haze Index on the 20% haziest sample days and the 20% clearest sample days. For FLNI, the Haze Index for mid-range days was used in the NRCA. Data from a nearby IMPROVE monitoring station (Monitor ID: FRRE1, MD) were used due to lack of data at FLNI (Taylor 2017).

Reference Conditions

- As an air quality indicator, visibility was considered in good condition if Haze Index scores of less than 2 dv were observed. Scores ranging from 2 dv to 8 dv warranted moderate concern, and scores greater than 8dv warranted significant concern.

Condition and Trend

A Haze Index of 8.6 dv was calculated for FLNI; this score warranted significant concern for this air quality indicator (NPS-ARD 2018) (Table 4-2). However, trend analysis suggests conditions are improving (based on 2006 to 2015; NPS-ARD 2018).

Table 4-2. Condition, trend, and confidence scores for Visibility, an air quality indicator in the Flight 93 National Memorial (FLNI) Natural Resource Condition Assessment (NRCA). NRCA Data supplied by the National Park Service Air Resources Division (NPS-ARD) (2018), and methods of scoring follow Taylor (2017).

Indicator	Metric	Status and Trend	Rationale and Reference Conditions
Visibility	Haze index		• **Condition**: Visibility warrants significant concern at FLNI. • **Trend**: For 2006–2015, the trend in visibility at FLNI has improved. • **Confidence**: High; nearby visibility monitor.

Level of Confidence and Data Gaps

Data were collected from a nearby IMPROVE monitoring station (Monitor ID: FRRE1, MD), and were scored as high confidence (NPS-ARD 2018). On-site monitoring stations at FLNI could improve data quality for visibility.

Source(s) of Expertise

- Data for the NRCA were supplied by NPS-ARD (Taylor 2017). Guidance for interpretation and inclusion in the NRCA were provided by Holly Salazer at NPS-NERO. Detailed methods can be found in the National Park Service Air Quality Analysis Methods (Taylor 2017).

Air Quality - Wet Deposition

Estimates of nitrogen and sulfur deposition warrant significant concern at FLNI. Estimates of mercury wet deposition and predicted methylmercury concentration warrant moderate concern at FLNI. NPS-ARD estimated that FLNI is experiencing similar levels of nitrogen and sulfur deposition

as other NPS sites in the region; the potential for soil and/or water acidification that results from these pollutants could negatively impact forest communities, wetlands, and streams at FLNI. Metrics for wet deposition were estimated for FLNI using spatial interpolation methods, which reduces confidence in these estimates (medium confidence). On-site monitoring stations would improve estimates of wet deposition at FLNI.

Resource Description

Nitrogen and sulfur are naturally found in terrestrial and aquatic ecosystems. However, human activity (e.g. burning of fossil fuels by power plants, vehicles and heavy equipment, agriculture, and industry) has contributed to an excess of atmospheric nitrogen and sulfur (nitrogen oxides and sulfur oxides) (EPA 2017b; EPA 2018c). Excess nitrogen and sulfur are deposited in soil and water through wet deposition (e.g. rain or snow) and/or dry deposition (e.g. gravitational settling of particles on the surface of water, plants, or soil; EPA 2017b; EPA 2018c), and has the potential to negatively impact aquatic and terrestrial ecosystems at multiple levels.

At FLNI, nitrogen deposition that results from excess nitrogen in the atmosphere could negatively impact plant communities. Sullivan et al. (2011) provided valuable insight into potential ecosystem sensitivity for NPS sites within NPS Inventory and Monitoring Networks, which is also applicable to FLNI given that many of the NPS sites in the Sullivan et al. (2011) report are found in the same region as FLNI. In addition to their shared geography, many NPS sites in the Eastern Rivers and Mountains network are managed as historic sites and national memorials and provide a management context that is similar to FLNI. Sullivan et al. (2011) summarized risk factors according to park composition (sensitive vegetation types, high elevation streaks and lakes, topography, sensitive habitats), levels of protection offered by the park (amount of park lands receiving special protection, amount of land classified as wilderness areas, etc.), and nitrogen and sulfur pollution variables (estimated deposition on land within parks, deposition within the county(s) that contains the park, and deposition within counties within 100 miles of the park). Sites within the Eastern Rivers and Mountain network were among the highest exposure risk areas for nitrogen and sulfur (acidification risk) and ranked high for ecosystem sensitivity. ALPO, FONE, FRHI, and FONE were ranked as either high or very high for nitrogen and sulfur pollution exposure and ecosystem sensitivity. FLNI should also be considered vulnerable to nitrogen and sulfur pollution, as FLNI protects similar natural communities and aquatic resources as nearby NPS sites within the Eastern Rivers and Mountains network. The Eastern Rivers and Mountain network also received a score of very low in its park protection score. This suggest that NPS sites within this Network may lack natural area protections to mitigate the impacts of nitrogen and sulfur pollution.

Similar to other air quality indicators in the FLNI NRCA, mercury pollution is primarily a result of human activity. Of all sources of mercury pollution, fossil fuel combustion is responsible for the majority of airborne mercury (about 42%; EPA 2018d), which has the potential to move great distances before it is deposited in soils or water (EPA 2018d). Mercury poses a significant threat to human health. Humans are most likely to encounter methylated (organic) mercury, but humans can also be negatively impacted by exposure to elemental mercury or inorganic mercury. In humans, methylated mercury exposure occurs (most often) through the consumption of fish or shellfish (EPA

2018e). In adults, methylated mercury can impact vision, coordination, speech, and ambulation (EPA 2018e). Infants and children are considered to be more vulnerable to the effects of mercury exposure than adults. In these populations, exposure to mercury can also lead to mental or muscular impairment (EPA 2018e). Mercury can also negatively impact birds and mammals by slowing or impeding reproduction and development, causing abnormal behavior, or death. Those birds and mammals that consume fish are at greatest risk for mercury exposure (EPA 2018e).

Data and Methods

NPS-ARD uses wet deposition as a surrogate for total deposition (i.e., wet plus dry deposition) for both nitrogen deposition and sulfur deposition. The network for wet deposition monitoring stations is robust (National Atmospheric Deposition Program/National Trends Network (NADP/NTN) (Taylor 2017) and collects information on wet deposition on ammonium, nitrate, sulfate, nitrogen, and sulfur; average precipitated weighted mean concentrations are calculated over a 5-year time frame. No wet deposition monitoring stations for nitrogen or sulfur are present at FLNI, and all wet deposition values used for the NRCA are estimates based on spatial interpolation. Spatial interpolation (Inverse weighted distance, IDW) was used to extrapolate wet deposition data for nitrogen and sulfur to areas without monitoring stations (for full methods, see Taylor 2017).

The NADP/NTN network collects information on wet deposition on mercury; average precipitated weighted mean concentrations are calculated over a 3-year time frame (Taylor 2017). Wet deposition monitoring stations for mercury do not exist at FLNI; therefore, spatial interpolation (Inverse weighted distance, IDW) was used to extrapolate wet deposition data for mercury at FLNI from surrounding areas with stations (see Taylor (2017) for full methods). Units for mercury wet deposition are micrograms per square meter per year ($\mu g/m^2/yr$) and are scored as follows: very low (< 3), low (≥ 3 and < 6), moderate (≥ 6 and < 9), high (≥ 9 and < 12), or very high (≥ 12). Predicted methylmercury concentration represents a measure of landscape sensitivity to deposited mercury (Taylor 2017). Predicted methylmercury concentrations are derived from modeled data (USGS 2015), and the value presented in the FLNI NRCA represents the highest value for predicted methylmercury concentrations that were measured for all hydrologic units relevant to FLNI. Predicted methylmercury concentration was assigned a rating of very low (< 0.038), low (≥ 0.038 and < 0.053), moderate (≥ 0.053 and < 0.075), high (≥ 0.075 and < 0.12), or very high (≥ 0.12).

Reference Conditions

- Air quality was considered in good condition with regard to nitrogen or sulfur if wet deposition occurred at a rate less than 1 kg/ha/yr; scores ranging from 1 to 3 kg/ha/yr warranted moderate concern, and scores greater than 3 kg/ha/yr warranted significant concern.

- NPS-ARD analyzes mercury risk status through an assessment matrix, a method of combining wet deposition (mercury input) and predicted methylmercury concentration (sensitivity) into a single condition score (Taylor 2017; Table 4-3). Taylor (2017) suggested that both measurements must be considered, as wet deposition of mercury, by itself, is not sufficient enough to assess on-the-ground conditions: mercury must be methylated before it can impact biological systems, and the USGS (2015) model accounts for environmental

conditions in a landscape that facilitate that conversion of mercury into a methylated state. Mercury data were provided by Taylor (personal communication, 2019).

Table 4-3. The National Park Service Air Resources Division (NPS-ARD) condition scoring criteria for mercury indicator condition scoring, as reported in Taylor (2017).

Status	Wet deposition very low	Wet deposition low	Wet deposition moderate	Wet deposition high	Wet deposition very high
Predicted methylmercury **very low**					
Predicted methylmercury **low**					
Predicted methylmercury **moderate**					
Predicted methylmercury **high**					
Predicted methylmercury **very high**					

Condition and Trend

Data derived from spatial interpolation methods suggested a wet deposition rate of nitrogen of 4.3 kg/ha/yr at FLNI. According to NPS-ARD benchmarks (Taylor 2017), this level of wet deposition of nitrogen warranted significant concern at FLNI (Table 4-4).

Data derived from spatial interpolation methods suggested a wet deposition rate of sulfur of 3.4 kg/ha/yr at FLNI. According to NPS-ARD benchmarks (Taylor 2017), this level of wet deposition of sulfur warranted significant concern at FLNI (Table 4-4).

Data derived from spatial interpolation methods suggests a range of wet deposition rate of mercury of 7.9 – 8.1µg/m^2/yr at FLNI. The USGS (2015) suggests predicted methylmercury concentration of 0.086ng/L, the highest observed value among hydrologic units relevant to FLNI (Table 4-5).

Table 4-4. Condition, trend, and confidence scores for wet deposition of nitrogen and sulfur, air quality indicators in the Flight 93 National Memorial (FLNI) Natural Resource Condition Assessment (NRCA). Data supplied by the National Park Service Air Resources Division (NPS-ARD) (2018) and methods of scoring follow Taylor (2017).

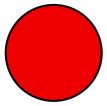
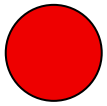
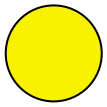
Indicator	Metric	Status and Trend	Rationale and Reference Conditions
Nitrogen	Wet deposition		• **Condition**: Wet nitrogen deposition warrants significant concern at FLNI. • **Trend**: No trend information is available; insufficient on-site or nearby deposition monitoring data. • **Confidence**: Medium; estimates are based on interpolated data from more distant deposition monitors.
Sulfur	Wet deposition		• **Condition**: Wet nitrogen deposition warrants significant concern at FLNI. • **Trend**: No trend information is available; insufficient on-site or nearby deposition monitoring data. • **Confidence**: Medium; estimates are based on interpolated data from more distant deposition monitors.

Table 4-5. Condition, trend, and confidence scores for wet deposition of Mercury, an air quality indicator in the Flight 93 National Memorial (FLNI) Natural Resource Condition Assessment (NRCA). Data supplied by Taylor (personal communication, 2019), and methods of scoring follow Taylor (2017).

Indicator	Metric	Status and Trend	Rationale and Reference Conditions
Mercury	Wet deposition and predicted methylmercury concentration		• **Condition**: A matrix assessment of wet deposition of mercury and predicted methylmercury concentration suggests. • **Trend**: No trend information is available; insufficient on-site or nearby deposition monitoring data. • **Confidence**: Medium; estimates are based on interpolated data from more distant deposition monitors.

Level of Confidence and Data Gaps

The degree of confidence for nitrogen, sulfur, and mercury wet deposition rates at FLNI are medium; these estimates are based on interpolated data from more distant deposition monitors.

Source(s) of Expertise

- Data for the NRCA were supplied by NPS-ARD (Taylor 2017). Guidance for interpretation and inclusion in the NRCA was provided by Holly Salazer at NPS-NERO. Detailed methods can be found in the National Park Service Air Quality Analysis Methods (Taylor 2017).

- Mercury data provided by K. Taylor (personal communication, 2019).

Night Sky and Acoustic Quality

Night Sky

Ambient light ratio (ALR) was used as a metric for Night Sky. ALR scores for FLNI suggest the resource is in good condition. Good night sky conditions benefit visitors during nighttime programming. Wildlife that occupy the park on a permanent or a migratory basis also benefit from good night sky conditions.

Indicator Description

Night sky conditions in a park can be an important aspect of the visitor experience. Artificial light can significantly pollute night skies, thus altering the ambience/experience for human visitors (if indeed the park is open for nighttime visitation). Artificial night light also has the potential to alter the habitat quality for the fauna that use it. NPS Natural Sounds and Night Sky Division (NSNSD) developed a classification system for parks to quickly assess night sky condition, taking into consideration the park resources and mandates. Parks are classified into two levels: (1) Level 1 parks contain significant natural resources that could be impacted by light pollution at night, and (2) Level 2 parks do not possess significant natural resources and are therefore considered less at risk from the detrimental effects of light pollution. FLNI is considered a Level 2 park. FLNI is open sunrise to sunset so night sky conditions may be less of a relevant issue from a visitation quality standpoint.

Since visitation is limited at FLNI beyond dusk, the focus of preserving night skies may be more important for wildlife that utilize FLNI on an ephemeral or permanent basis. FLNI provides habitat for a variety of birds, both migrant and year-round residents (see Appendix A). It is also located at the northern end of the Allegheny Mountains which is also considered a moderately important area for migrating birds (Buler et al. 2017. During migration, excess ambient light can result in disorientation (Cabera-Cruz et al. 2018). Changes in ambient light conditions may also affect bird reproduction. Miller (2006) detected an association between ambient light and chorus initiation for American robin (*Turdus migratorius*) at civil twilight, which may have implications for reproduction in sites receiving increased ambient light.

Other species, such as amphibians and invertebrates, may be impacted as well. Dananay and Bernard (2018) found that artificial light at night reduced the amount of time required for metamorphosis in American toads (*Anaxyrus americanus*), and reduced growth during juvenile stages. Hagen et al. (2015) documented a decline in lightning bug activity in response to artificial light. At the community level, Davies et al. (2012) suggested that artificial light pollution from street lights impact not only aerial invertebrates, but also ants, amphipods, ground beetles, and some orders of arachnids (e.g. daddy-longlegs). These invertebrates were more abundant in areas that were illuminated by streetlights, and predator/scavenger activity was enhanced by the presence of more invertebrates in well-lit areas.

Moths are important pollinators in many ecosystems and could also be negatively impacted by light pollution. Altermatt and Ebert (2016) noted that moths collected from urban populations, and reared in a controlled garden setting, showed reduced movement behavior towards light. Altermatt and Ebert (2016) suggest this reduction in mobility could reduce colonization potential for moths

originating from urban populations. There is evidence that artificial light can reduce moth species richness and abundance in alpine meadows (Knop et al. 2017), and similar moth community impacts could occur in temperate deciduous forests like those found at FLNI.

Data and Methods

NPS NSNSD recommended a single parameter, ambient light ratio (ALR), to assess the ratio of natural light to ambient light. An ALR ratio of 1.0 would indicate that anthropogenic light was 100% brighter than natural light, while an ALR of 0.0 would indicate a complete absence of anthropogenic light. Average night sky brightness is 78 nanolamberts (nL; measure of luminescence). At this level, night sky features such as the Milky Way and zodiacal light (Moore et al. 2013) are visible. Site-specific measurements for sky brightness, which were used to calculate ALR, were not available for FLNI. Instead, ALR data for FLNI were extracted from a GIS model (Duriscoe et al. 2018; other modeling techniques are available in Moore et al 2013).

Reference Conditions

FLNI is considered a Level 2 Park; a Level 2 park is not recognized by NRSS I&M as having significant natural resources (Moore et al. 2013), and therefore, light pollution is thought to have less of an impact on wildlife at FLNI. Night sky was considered in good condition at FLNI if ALR was less than 2 for 50% of the sample site, an ALR of 2–18 warranted moderate concern, while ALR greater than 18 warranted significant concern.

Condition and Trend

An overall average ALR score for FLNI was 2 with most of FLNI (54%) having an ALR value of less than 2 (Figure 4-1, Table 4-6). According to the reference condition definition described in the previous section, FLNI is in good condition.

Table 4-6. Condition, trend, and confidence scores for night sky, an indicator of Night Sky and Acoustic Quality in the Flight 93 National Memorial (FLNI) Natural Resource Condition Assessment (NRCA). Data supplied by the National Park Service Natural Sounds and Night Skies Division (NPS NSNSD) (see Duricsoe et al. 2018).

Indicator	Metric	Status and Trend	Rationale and Reference Conditions
Night sky	Ambient light ratio (ALR)		• **Condition**: 54% of FLNI had an ambient light ratio score of less than 2; based on conditions for level 2 parks, resource is in good condition. • **Trend**: No trend information is available; insufficient on-site or nearby deposition monitoring data. • **Confidence**: Medium; estimates of ambient light ratio were obtained through interpolation.

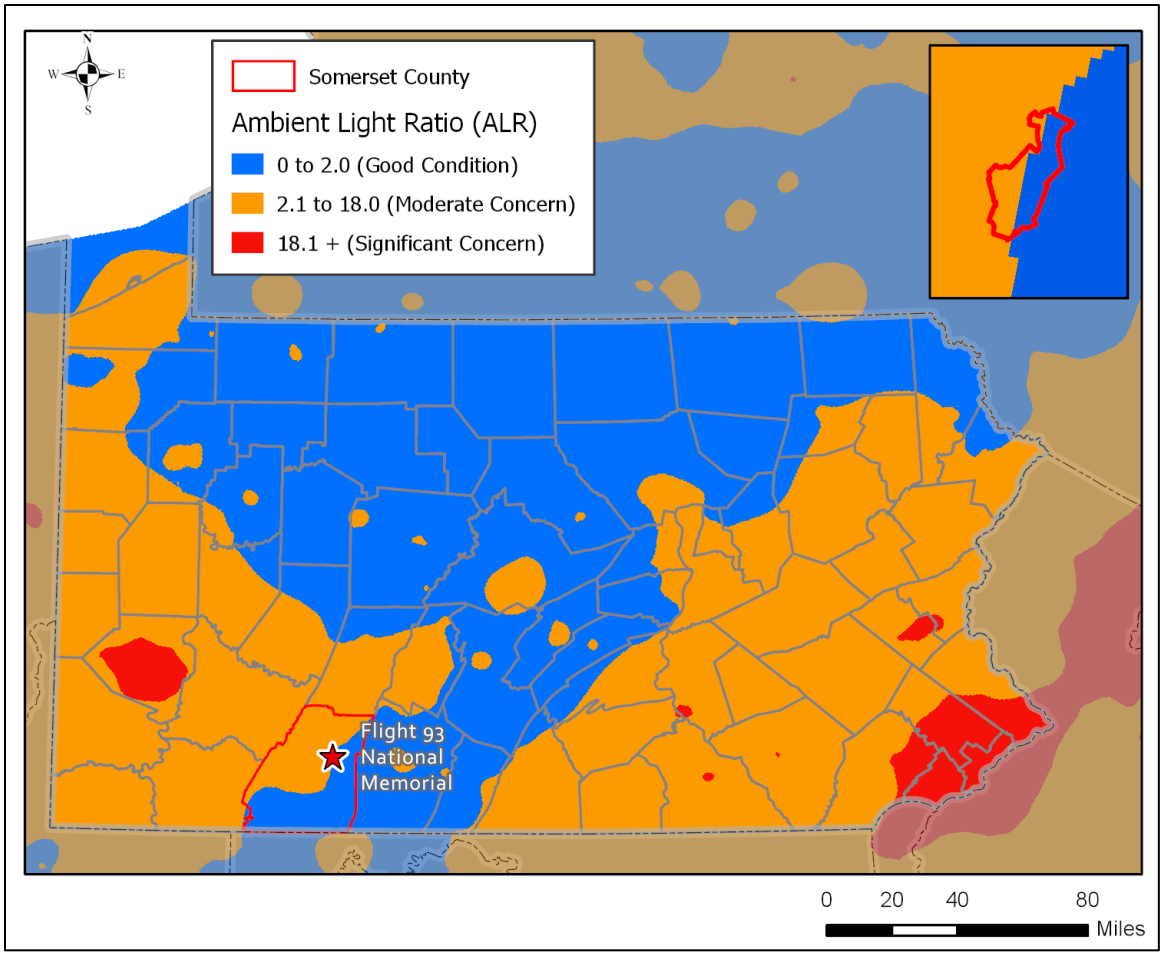


Figure 4-1. Regional view of ambient light ratio categories for Flight 93 National Memorial. Data supplied by the National Park Service Natural Sounds and Night Skies Division (NPS NSNSD) (see Duriscoe et al. 2018).

Level of Confidence and Data Gaps

The degree of confidence for average ALR for FLNI is medium. ALR score is based on a dataset that was generated from spatial interpolation (see Duriscoe et al. 2018).

Source(s) of Expertise

- The NSNSD preserves and restores night sky environments, increases scientific understanding, and inspires public appreciation of natural night skies. They provide technical assistance to parks in the form of night sky monitoring, data collection and analysis, and in understanding night sky conditions for planning and reporting purposes.

Soundscapes

L50 dBA impact score is used as a metric for Soundscapes. Sound conditions at FLNI warrant significant concern. Anthropogenic sources of sound could negatively impact visitor experience and wildlife at FLNI.

Indicator Description

Visitors to national parks often indicate that an important reason for visiting the parks is to enjoy the relative quiet that parks can offer. In a 1998 survey of the American public, 72% of respondents identified opportunities to experience natural quiet and the sounds of nature as an important reason for having national parks (Haas and Wakefield 1998). Additionally, 91% of NPS visitors "consider enjoyment of natural quiet and the sounds of nature as compelling reasons for visiting national parks" (McDonald et al. 1995). Despite this desire for quiet environments, anthropogenic noise continues to intrude upon natural areas and has become a source of concern in national parks (Lynch et al. 2011).

Sound not only impacts the human experience but also affects wildlife as well. A growing number of noise-focused studies show that animals, like humans, are stressed by noisy environments (Shannon et al. 2016). Shannon et al. (2016) conducted an extensive literature review on the effects of anthropogenic noise on wildlife. They found that studies have been conducted across taxonomic groups and included a range of terrestrial and aquatic habitats. However, birds and marine mammals were by far the most studied groups. Since birds are an important biological resource at FLNI (see 4.4.1), it is therefore useful to understand the effects of anthropogenic noise on this taxonomic group. Shannon et al. (2016) summarized some biological responses of birds to noise which includes changes in vocalization (frequency components, amplitude, shifts in timing), changes in songs (call rate and duration, frequency and length), increase in physiological stress, increase in vigilance and alert behavior, reduced breeding success, and declines in occupancy and abundance. In another scientific review, Ortega (2012) indicated several other effects of noise on birds which includes physical damage to ears, fright-flight responses, changes in behavioral responses such as foraging, changes in reproductive success, interference with the ability to hear predators and other important sounds, and potential changes in populations.

The natural soundscape is an inherent component of "the scenery and the natural and historic objects and the wildlife" protected by the Organic Act of 1916. NPS Management Policies (§ 4.9) require the NPS to preserve the park's natural soundscape and restore the degraded soundscape to the natural condition wherever possible. Additionally, NPS is required to prevent or minimize degradation of the natural soundscape from noise (i.e., inappropriate/undesirable human-caused sound). Although the management policies currently refer to the term soundscape as the aggregate of all-natural sounds that occur in a park, differences exist between the physical sound sources and human perceptions of those sound sources. The physical sound resources (i.e., wildlife, waterfalls, wind, rain, and cultural or historical sounds), regardless of their audibility at a particular location, are referred to as the acoustic environment, while the human perception of that acoustic environment is defined as the soundscape. Clarifying this distinction will allow managers to create objectives for safeguarding both the acoustic environment and the visitor experience.

Data and Methods

In cases where the ability to collect acoustic data on site is limited, alternatives for assessing condition and trend are also available. NPS NSNSD has developed a sound model which predicts natural and existing sound levels with 270-meter resolution (Mennitt et al. 2013). The model was generated using machine learning algorithms to predict acoustic conditions across the contiguous

United States. Model inputs included A-weighted sound level measurements (dB $L_{Aeq,1s}$ from 20 Hz to 20 kHz) at 492 sites and associated geospatial features (e.g. vegetation, topography, climate, hydrology, and anthropogenic activity) for each site. Using the geospatial features, the model predicts the sound level exceeded 50% of the time (L_{A50}, median). Predicted sound levels represent average summer daytime hours (July–September; 7 a.m. to 7 p.m.) at a 270 m^2 resolution. By minimizing anthropogenic features, the model also predicts natural conditions, referred to as predicted summer daytime (7am—7pm) natural sound level (predicted $L_{A50, natural}$).

The difference between existing and natural conditions provides an estimate of the amount that anthropogenic sound energy raises the existing sound levels above natural, also referred to as noise impact (predicted $L_{A50, impact}$). A predicted $L_{A50, impact}$ level of 1.5 dB reduces the listening area of wildlife and humans by 30%, while a predicted $L_{A50, impact}$ level of 3.0 dB would reduce the listening area by 50%.

Humans and wildlife perceive sound as an auditory sensation created by pressure variations that move through a medium such as water or air. Sound is measured in terms of frequency and amplitude (Templeton and Sacre 1997, Harris 1998). Noise, essentially the negative evaluation of sound, is defined as extraneous or undesired sound (Morfey 2000). Frequency, measured in Hertz (Hz), describes the cycles per second of a sound wave, and is perceived by the ear as pitch. Humans with normal hearing can hear sounds between 20 Hz and 20,000 Hz and are most sensitive to frequencies between 1,000 Hz and 6,000 Hz. High frequency sounds are more readily absorbed by the atmosphere or scattered by obstructions than low frequency sounds. Low frequency sounds diffract more effectively around obstructions. Therefore, low frequency sounds travel farther.

Besides the pitch of a sound, we also perceive the amplitude (or level) of a sound. This metric is described in decibels (dB). The decibel scale is logarithmic, meaning that every 10 dB increase in sound pressure level (SPL) represents a tenfold increase in sound energy. This also means that small variations in sound pressure level can have significant effects on the acoustic environment. For instance, a 6 dB increase in a noise source will double the distance at which it can be heard, increasing the affected area by a factor of four. Sound pressure level is commonly summarized in terms of dBA (A-weighted sound pressure level). This metric significantly discounts sounds below 1,000 Hz and above 6,000 Hz to approximate human hearing sensitivity. Table 4-7 provides examples of A-weighted sound levels measured in national parks.

Human responses can serve as a proxy for potential impacts to other vertebrates because humans have more sensitive hearing at low frequencies than most species (Dooling and Popper 2007), so a resource assessment might also consider the time that SPL levels exceeded those mentioned in Table 4-8. The first value (35 dBA) is designed to address the health effects of sleep interruption. Recent studies suggest that sound events as low as 35 dB can have adverse effects on blood pressure while sleeping (Haralabidis et al. 2008). The second threshold addresses the World Health Organization's recommendations that noise levels inside bedrooms remain below 45 dBA (WHO 1999). Park visitors camping in or near the park could experience either of these two effects. The third level (52 dBA) is based on the EPA's speech interference threshold for speaking in a raised voice to an audience at 10 meters. This threshold addresses the effects of noise on interpretive programs in parks.

The final threshold (60 dBA) provides a basis for estimating impacts on normal voice communications at 1 meter. Hikers and visitors viewing scenic vistas in the park would likely be conducting such conversations. The natural acoustic environment is vital to the function and character of a national park. Natural sounds include those sounds upon which ecological processes and interactions depend. Examples of natural sounds in parks include sounds produced by birds, frogs or insects to define territories or attract mates, sounds produced by bats to navigate or locate prey, and sounds produced by physical processes such as wind in trees, flowing water, or thunder. Although natural sounds often dominate the acoustic environment of a park, human-caused noise has the potential to mask these sounds. Noise impacts the acoustic environment much like smog impacts the visual environment; obscuring the listening horizon for both wildlife and visitors. Examples of human-caused sounds heard in parks include, aircraft (i.e., high-altitude and military jets, fixed-wing, helicopters), vehicles, generators, watercraft, grounds care (lawn mowers, leaf blowers), and human voices.

Table 4-7. Examples of sound levels measured in national parks.

Decibel Level (dBA)	Sound Source
10	Volcano crater (Haleakala National Park)
20	Leaves rustling (Canyonlands National Park)
40	Crickets at 5m (Zion National Park)
60	Conversation speech at 5m (Whitman Mission National Historic Site)
80	Motorcycle at 30m (Blue Ridge Parkway)
100	Thunder (Arches National Park)
120	Military jet, 100m above ground level (Yukon-Charley Rivers National Park)
126	Cannon fire at 150m (Vicksburg National Military Park)

Table 4-8. Examples of sound levels measured in national parks.

SPL (dBA)	Relevance
35	Blood pressure and heart rate increase in sleeping humans (Haralabidis et al. 2008)
45	World Health Organization's recommendation for maximum noise levels inside bedrooms (Berglund et al. 1999)
52	Speech interference for interpretive programs (EPA 1974)
60	Speech interruption for normal conversation (EPA 1974)

Oftentimes, managers characterize ambient conditions over the full extent of the park by dividing total area into "acoustic zones" on the basis of different vegetation zones, management zones, visitor use zones, elevations, or climate conditions. Then, the intensity, duration, and distribution of sound sources in each zone can be assessed by collecting sound pressure level (SPL) measurements, digital audio recordings, and meteorological data. Indicators typically summarized in resource assessments include natural and existing ambient sound levels and types of sound sources. Natural ambient sound level refers to the acoustical conditions that exist in the absence of human-caused noise and

represents the level from which the NPS measures impacts to the acoustic environment. Existing ambient sound level refers to the current sound intensity of an area, including both natural and human-caused sounds.

To assess the condition of the acoustic environment, it is also useful to consider the functional effects that increases in sound level might produce. For instance, the listening area, the area in which a sound can be perceived by an organism, will be reduced when background sound levels increase. The failure to perceive a sound because other sounds are present is called masking. Masking interferes with wildlife communication, reproductive and territorial advertisement, and acoustic location of prey or predators (Barber, Crooks, and Fristrup 2010). However, the effects of masking are not limited to wildlife. Masking also inhibits human communication and visitor detection of wildlife sounds. In urban settings, masking can prevent people from hearing important sounds like approaching people or vehicles and interfere with the way visitors experience cultural sounds or interpretive programs. Keep in mind that seemingly small increases in sound level can have substantial effects, particularly when quantified in terms of loss of listening area (Payne and Webb 1971; Barber, Crooks, and Fristrup 2010). Each 3 dB increase in the background sound level will reduce a given listening area by half. See Table 4-9 for additional information.

Table 4-9. Increases in background sound level (dB) with resulting decreases in listening area.

Increase in Background Sound (dB)	Decrease in Listening Area
1	21%
2	37%
3	50%
4	60%
5	68%
6	75%
7	80%
8	84%
9	87%
10	90%

The influence of anthropogenic noise on the acoustic environment is generally reported in terms of SPL across the full range of human hearing (12.5–20,000 Hz), but it is also useful to report results in a much narrower band (20–1250 Hz) because most human-caused sound is confined to these lower frequencies.

Because the NPS is comprised of a wide variety of park units, two threshold categories are considered (urban and non-urban), based on proximity to urban areas (U.S. Census Bureau 2010). The urban criteria are applied to park units that have at least 90% of the park property within an

urban area. The non-urban criteria were applied to units that have at least 90% of the park property outside an urban area. Parks that are distant from urban areas possess lower sound levels, and they exhibit less divergence between existing sound levels and predicted natural sound levels. These quiet areas are more susceptible to subtle noise intrusions than urban areas. In non-urban areas, visitors and wildlife have a greater expectation for noise-free environments. Accordingly, the thresholds for the amber and red condition ratings are lower for these park units than for units near urban areas. Urban areas tend to have higher ambient sound levels than non-urban areas (EPA 1971; Schomer et al. 2011). Higher thresholds are used for parks in urban areas. However, acoustic environments are important in all parks: units in urban areas may seek to preserve or restore low ambient sound levels to offer respite for visitors. FLNI is considered a non-urban park.

Reference Conditions

- Ambient sound was considered to be in good condition if mean L50 impact score was equal to or less than 1.5dBA; mean L50 impact scores between 1.5 and less than or equal to 3.0 warranted moderate concern, while mean L50 impact scores greater than 3.0 warranted significant concern.

Condition and Trend

Mean L50 Impact, extracted from modeled data at FLNI, had a value of 5.1 (Figure 4-2). This score warranted significant concern for soundscape condition at FLNI (Table 4-10). Mean L50 impact score was based on a single dataset, and trend could not be determined for this metric at FLNI.

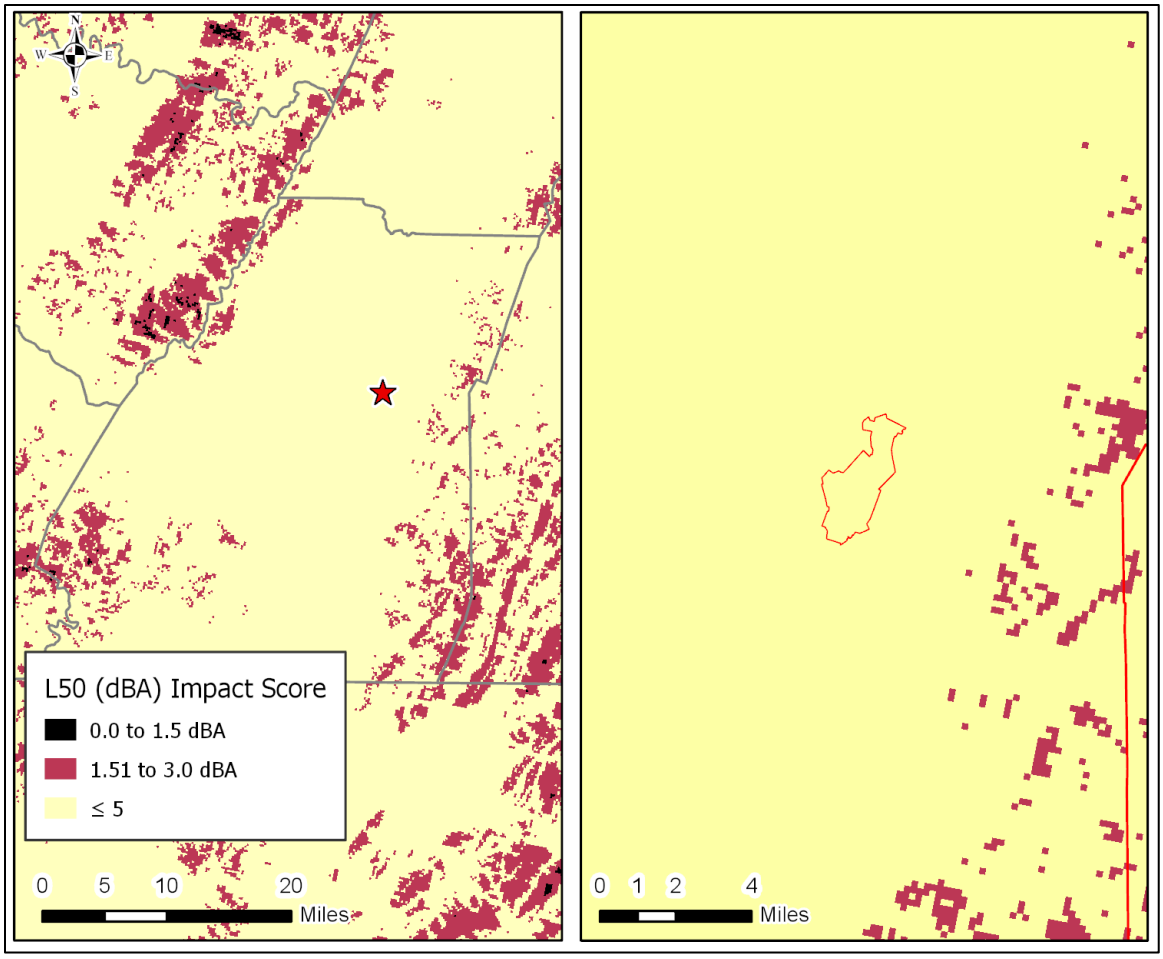
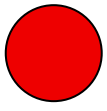


Figure 4-2. Map of L50 (dBA) impact scores for Flight 93 National Memorial (FLNI). Mean L50 (dBA) impact was used as a metric to score condition of soundscapes, a component of Night Sky and Acoustic Quality at FLNI. Data derived from Mennitt et al. (2013).

Table 4-10. Condition, trend, and confidence scores for soundscapes in the Flight 93 National Memorial (FLNI) Natural Resource Condition Assessment (NRCA). Data supplied by the National Park Service Natural Sounds and Night Skies Division (NPS NSNSD) (see Duriscoe et al. 2018).

Indicator	Metric	Status and Trend	Rationale and Reference Conditions
Soundscapes	L50 DBA impact score		• **Condition**: mean L50 (dba) score of 5.09; this score warranted significant concern; listening area could be reduced by greater than 50%. • **Trend**: No trend information is available; insufficient on-site or nearby deposition monitoring data. • **Confidence**: Medium; L50 (dba) impact scores based on interpolation.

Level of Confidence and Data Gaps

Baseline acoustic ambient data collection will clarify existing conditions and provide greater confidence in resource condition trends. Wherever possible, baseline ambient data collection should be conducted. In addition to providing site specific information, this information can also strengthen the national noise model.

Source(s) of Expertise

- The NSNSD preserves and restores acoustic environments, increases scientific understanding, and inspires public appreciation of soundscapes. They provide technical assistance to parks in the form of acoustical monitoring, data collection and analysis, and in understanding acoustic conditions for planning and reporting purposes.

- Data were provided by NPS NSNSD (Mennitt et al. 2013).

Stream Water Quality

Water Chemistry

Alkalinity, aluminum, iron, and pH were the water chemistry metrics used to determine water quality at one monitoring station (LRS-30) on Lamberts Run within FLNI. Based on 2009 water quality data, the water quality of Lamberts Run, downstream of the passive AMD treatment system, is in good condition according to PA water chemistry standards (PA Code §93.7). Trend in data from 2001–2009 show consistent improvement of water quality conditions at LRS-30. Monitoring should be reestablished at this site and implemented at Grove Run. Grove Run also originates within FLNI boundaries but is not currently monitored.

Indicator Description

Two streams originate within FLNI boundaries, Lamberts Run and Grove Run. Both streams are tributaries to the Stonycreek River and are classified as cold-water fisheries (CWFs). CWFs are defined in Title 25 (Environmental Protection) PA Code Chapter 93 as being important for the maintenance and/or propagation of flora and fauna that are "indigenous to a cold-water habitat" (25 Pa. Code § 93.3). Little information is available for Grove Run. On the other hand, Lamberts Run has received significant research attention over the past 20 years. Lamberts Run is affected by AMD, which degrades water quality in Lamberts Run and the Stonycreek River (Deal et al. 2008). The Somerset County Conservation District (SCCD) reported a decline in the abundance and diversity of fishes in Stonycreek River downstream of its convergence with Lamberts Run (SCCD 2018). The SCCD also documented a "low quality" macroinvertebrate community in the Stonycreek River downstream of Lamberts Run (SCCD 2018)

Since 1998, a number of passive treatment systems at FLNI and on private property along Lamberts Run were established to help mitigate some of the impacts of AMD on water quality. In 2012, Pennsylvania Department of Environmental Protection (PA DEP) utilized funds from the Office of Surface Mining Reclamation and Enforcement (OSMRE) to improve treatment facilities at FLNI (Himler 2016). The SCCD (2018) estimates that 0.11 tons of iron and 2.19 tons of aluminum are removed each year from passive treatment systems on Lamberts Run. Stream surveys completed by the Pennsylvania Fish and Boat Commission (PFBC) show increasing numbers of fish species in the Stonycreek River (SCCD 2018), which indicates water quality improvement in the Stonycreek River and its tributaries. In 2018, SCCD received an Environmental Achievement Award from the U.S. Department of the Interior (DOI) for AMD remediation work at FLNI

Data and Methods

PA DEP has multiple water quality monitoring stations established within the boundaries of and adjacent to FLNI (Figure 4-3 and 4-4). Most stations in FLNI are associated with historical surface mining disturbance and passive AMD treatment systems (i.e. channels and settling ponds), and would be a poor measure of water quality given their AMD contamination. Station LRS-30 is located on Lambert's Run within FLNI's boundary and is downstream of the passive AND treatment systems. Given that LRS-30 is the only station in FLNI that monitors water quality after AMD treatment, it was chosen as the appropriate station to use. Passive treatment structures undoubtedly improve water quality in Lamberts Run, but more natural stream settings only exist downstream of

these treatment systems. This NRCA does not attempt to score the condition (effectiveness) of AMD treatment systems, but does recognize their importance for improving downstream water chemistry.

For LRS-30, data were available from 2001 to 2009. Condition of water quality metrics were scored based on the 2009 dataset (the most recently available sampling year), from water samples collected in April and July. Because Lamberts Run is classified as a CWF, water chemistry metrics used to determine conditon included pH, alkalinity, iron, and aluminum. Standards for aluminum are not specific to CWF, as this is considered a toxic substance (Chapter 93 Water Quality Standards). None of the metrics used to score condition for Lamberts Run were seasonally dependent, so annual mean was calculated for each metric.

The majority of Lamberts Run (4.66 miles; 81%) is found on private property to the west of FLNI. Water chemistry data for these sampling locations (LRS-80, LRS-70, LRS-10, LRS-20; Figures 4-3 and 4-4) were summarized and presented graphically, as they provide water quality context for Lamberts Run as it leaves FLNI property. LRS-70 represents a sampling location just beyond FLNI boundaries (0.3 miles), and LRS-80 is located on a small, nearby tributary to Lamberts Run (Figure 4-4). LRS-20 is located along the main stem of Lamberts Run, about 1.6 miles from FLNI (stream distance) and about 1.5 miles from the Stonycreek River. LRS-10 is located near the confluence of Lamberts Run and the Stonycreek River (Figure 4-4, about 3 miles from FLNI. For these sampling locations, mean annual values for pH, specific conductance, alkalinity, iron, manganese, aluminum, sulfates, and total suspended solids were used to assess water quality.

No water chemistry data were available for Grove Run and has been identified as a data gap for this stream.

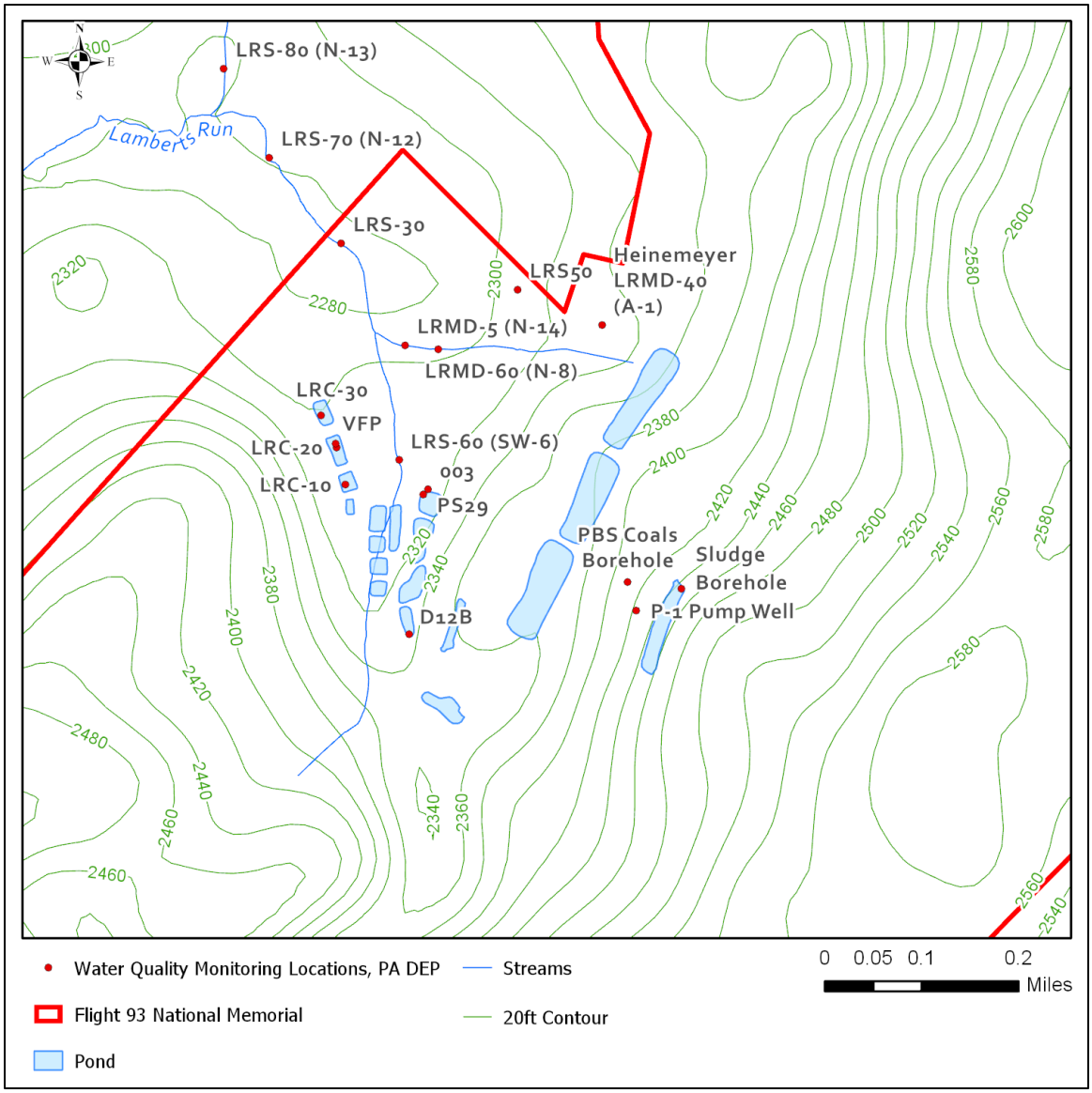


Figure 4-3. Map of the locations of past and present water quality monitoring stations for acid mine drainage treatment infrastructure and Lamberts Run at Flight 93 National Memorial (PA DEP 2018).

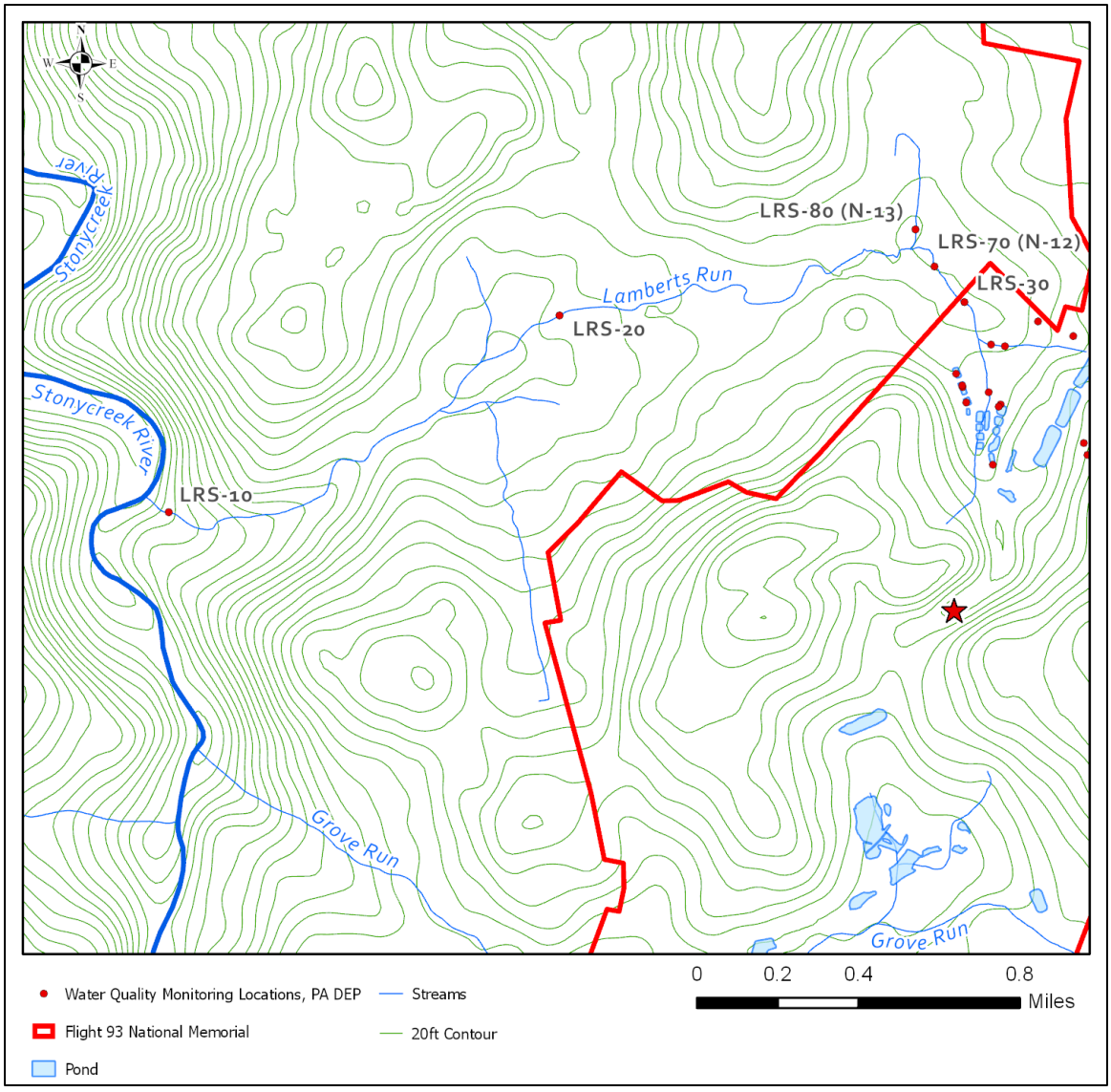


Figure 4-4. Water quality monitoring locations on Lamberts Run from the western border of Flight 93 National Memorial to the Stonycreek River (PA DEP 2018; SCCD 2018).

Reference Conditions/Values

- There are no standard criteria for scoring specific water chemistry metrics in the context of the NRCA. Each metric was scored using the same method employed in the NRCA for Gettysburg National Military Park and Eisenhower National Historic Site (James 2017). Instead of making assumptions about tolerances of stream biota to water chemistry metrics not meeting the standards of the appropriate stream designation, James (2017) considered how often the stream met water chemistry standards (PA Code §93.7) based on stream designation.
    - Good: water chemistry metric was within acceptable range as indicated by state water quality standards for > 75% of the sampling events.

- Moderate Concern: water chemistry metric was within acceptable state water chemistry standards for 25%-75% of sampling events.
- Significant Concern: water chemistry metric was within acceptable state water quality standards for <25% of sampling events.

- Pennsylvania (via PA Code §93.7) sets the following standards for CWF for pH, alkalinity, and iron.
  - pH falls between 6 and 9
  - Alkalinity values have a minimum value 20 mg/L.
  - Iron values (30-day average) are less than 1.5 mg/L.
- Pennsylvania (via PA Code §93.7) considers aluminum a toxic substance. Standards indicate that streams may have a maximum aluminum concentration of 750 µg/L. This applies to all streams, regardless of designation.

Condition and Trend

Condition and trend for FLNI was based on data collected at LRS-30, the only DEP sampling location in a more natural stream setting at FLNI (downstream of passive AMD treatment system). The following water chemistry metrics were recorded in 2009: a mean pH of 7.8, mean alkalinity of 90.1mg/L, mean iron concentration of 1.12mg/L, and mean aluminum concentration of less than 500µg/L. Based on Pennsylvania standards, all water chemistry metrics suggest that Lamberts Run is in good condition. Since monitoring was initiated in 2001, all water chemistry metrics have improved in Lamberts Run (Figures 4-5 through 4-8, Table 4-11).

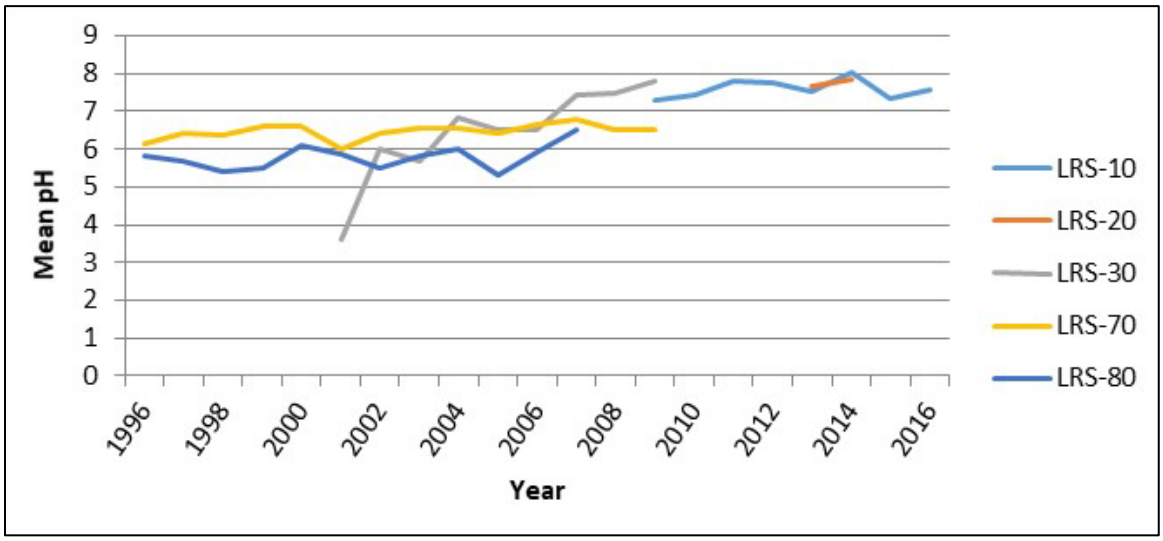


Figure 4-5. Mean annual pH from 1996 to 2016 for water quality monitoring locations along Lamberts Run in Flight 93 National Memorial. Monitoring locations have not been consistently sampled within this timeframe. Data supplied by PA DEP (2018).

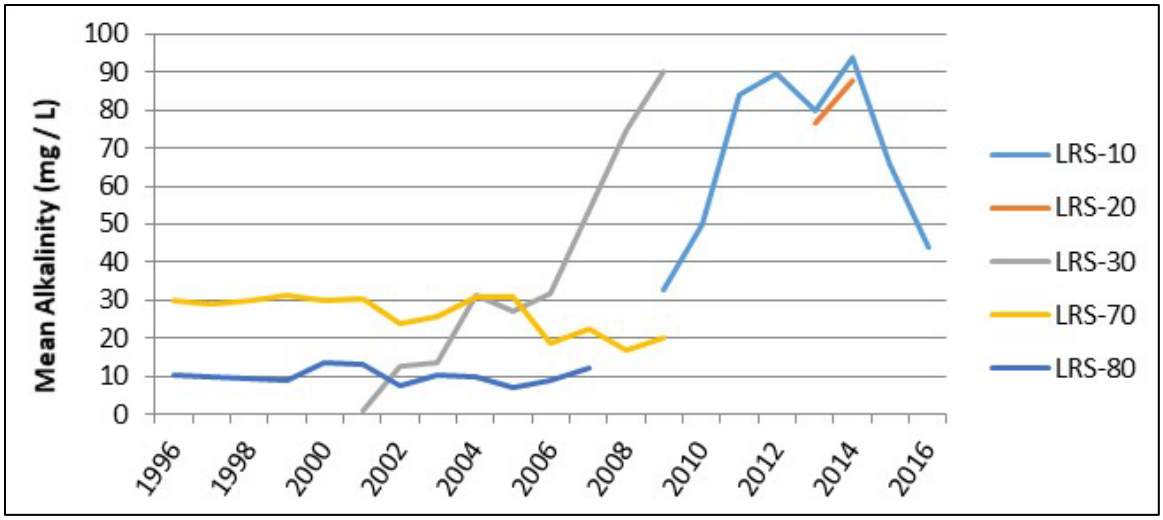


Figure 4-6. Mean annual alkalinity (mg/L) from 1996 to 2016 for water quality monitoring locations along Lamberts Run in Flight 93 National Memorial. Monitoring locations have not been consistently sampled within this timeframe. Data supplied by PA DEP (2018).

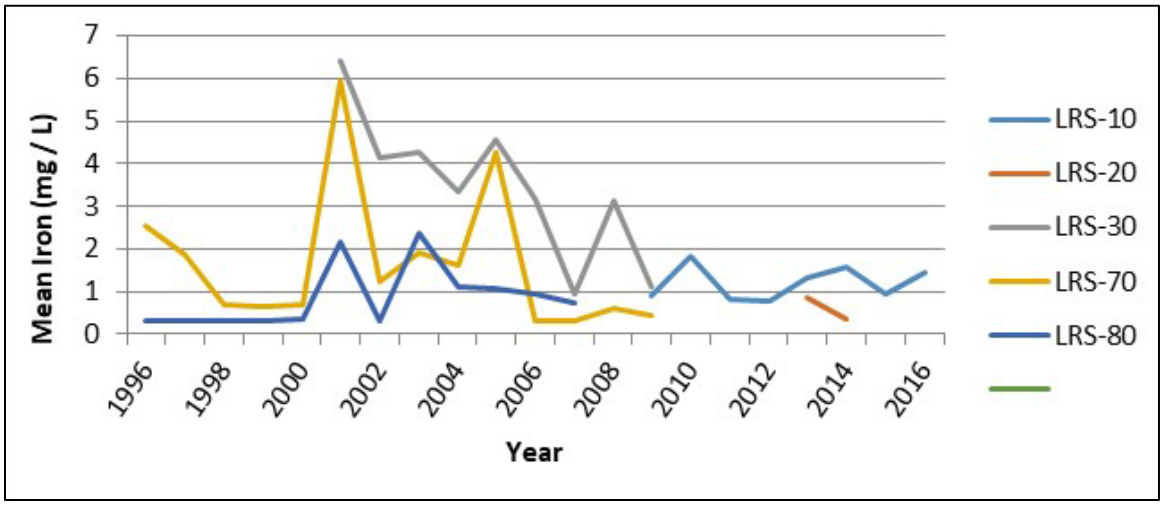


Figure 4-7. Mean annual iron (mg/L) from 1996 to 2006 for water quality monitoring locations along Lamberts Run in Flight 93 National Memorial. Monitoring locations have not been consistently sampled within this timeframe. Data supplied by PA DEP (2018).

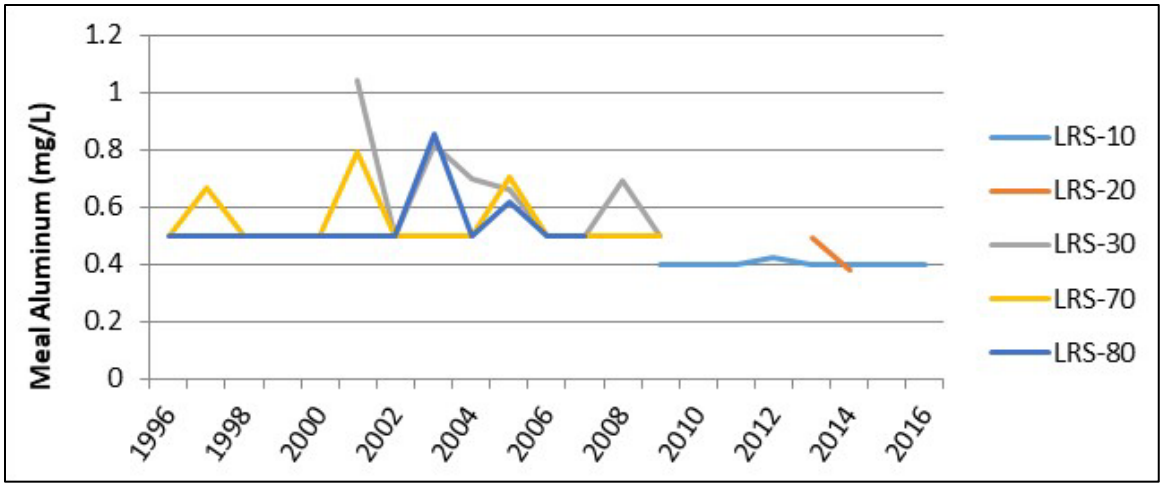
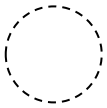
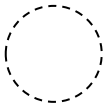


Figure 4-8. Mean annual aluminum (mg/L) from 1996 to 2006 for water quality monitoring locations along Lamberts Run in Flight 93 National Memorial. Monitoring locations have not been consistently sampled within this timeframe. Data supplied by PA DEP (2018).

Table 4-11. Summary of condition, trend, and confidence for water chemistry metrics, indicators of stream water quality in the Flight 93 National Memorial Natural Resource Condition Assessment (NRCA). Data supplied by the Pennsylvania Department of Environmental Protection (2018).

Indicator	Metric	Status and Trend	Rationale and Reference Conditions
pH	Mean pH		• **Condition**: in 2009, mean pH of LRS-30 in 2016 was 7.8; pH was in good condition in Lamberts Run downstream of acid mining drainage treatment infrastructure. • **Trend**: mean pH of stream water had risen at LRS-30 in Lamberts Run since sampling began in 2001; condition is improving. • **Confidence**: data were collected on site over multiple years (2001–2009), but recent data are not available; confidence is low.
Alkalinity	Mean alkalinity (mg/L)		• **Condition**: mean alkalinity was 90.10 mg/L at LRS-30 in Lamberts Run; downstream of acid mining drainage treatment infrastructure, alkalinity was in good condition in Lamberts Run • **Trend**: alkalinity of stream water had risen at LRS-30 in Lamberts Run since sampling began in 2001; conditions were improving. • **Confidence**: data were collected on site over multiple years (2001–2009), but recent data are not available; confidence is low.

Table 4-11 (continued). Summary of condition, trend, and confidence for water chemistry metrics, indicators of stream water quality in the Flight 93 National Memorial Natural Resource Condition Assessment (NRCA). Data supplied by the Pennsylvania Department of Environmental Protection (2018).

Indicator	Metric	Status and Trend	Rationale and Reference Conditions
Iron	Mean iron (mg/L)		• **Condition**: mean iron concentration was 1.12 mg/L at LRS-30 in Lamberts Run; downstream of acid mining drainage treatment infrastructure, mean iron concentration was in good condition in Lamberts Run. • **Trend**: mean iron concentration had decreased in stream water at LRS-30 in Lamberts Run since sampling began in 2001; conditions were improving. • **Confidence**: data were collected on site over multiple years (2001–2009), but recent data are not available; confidence is low.
Aluminum	Mean aluminum (mg/L)		• **Condition**: mean aluminum concentration was less than 0.5 mg/L at LRS-30 in Lamberts Run; downstream of acid mining drainage treatment infrastructure, mean aluminum concentration was in good condition in Lamberts Run. • **Trend**: mean aluminum concentration had decreased in stream water at LRS-30 in Lamberts Run since sampling began in 2001; conditions were improving. • **Confidence**: data were collected on site over multiple years (2001–2009), but recent data are not available; confidence is low.
Temperature	N/A		• **Condition**: no data were available; condition could not be scored. • **Trend**: no data were available; trend no able to be determined. • **Confidence**: no data were available; confidence low.
Specific conductance	N/A		• **Condition**: no data were available; condition could not be scored. • **Trend**: no data were available; trend no able to be determined • **Confidence**: no data were available; confidence low.

Level of Confidence and Data Gaps

Although water quality monitoring at FLNI was first established in 1998, water quality data from LRS-30 (the monitoring station used for this NRCA) was only collected for the timeframe of 2001 through 2009. Although other sources of AMD may exist along Lamberts Run, water chemistry data from LRS-10, LSR-20, LSR-70, and LSR-80 suggest that similar CWF standards have been met elsewhere in Lamberts Run (Figures 4-5 through 4-8). Monitoring efforts at LRS-30 should be

reinstated to provide current data for future assessments of water chemistry conditions in Lamberts Run at FLNI. Water temperature data should also be collected, as this is a very important parameter for assessing the status of Lamberts Run as a CWF.

Water quality data for Grove Run are not available. Grove Run receives inputs from reclaimed mine areas in FLNI and pastoral areas in both FLNI and private property then passes through ecological communities and culturally significant communities at FLNI. Because reclaimed mine and pastoral runoff can negatively impact water quality in Grove Run and may indirectly affect ecologically important areas, monitoring should also be implemented for this stream. Finally, specific conductance and temperature should be monitored in streams at FLNI. This will allow FLNI to more accurately determine if streams are meeting the Pennsylvania standards for CWFs.

Source(s) of Expertise

- Stream water chemistry data for Lamberts Run at FLNI were provided by PA DEP (2018) and SCCD (2018).

- Additional information for AMD treatment history, and regional context (Lamberts Run outside of FLNI; Stonycreek River) were provided by the Somerset Conservation District; reports and unpublished data provided by L. Lichvar (personal communication 2018).

Aquatic Macroinvertebrates

No data have been collected for aquatic macroinvertebrates in either Lamberts Run or Grove Run at FLNI. Therefore, no metrics were available to score condition and trend of aquatic macroinvertebrates at FLNI. However, natural resources such as these have been identified as park vital signs by the ERMN staff and throughout the NPS. Numerous protocols, data bases, and interpretative tools already exist within the NPS and other agencies to potentially assist the park should they attempt to address filling these data gaps in the future.

Indicator Description

Aquatic macroinvertebrates are important components of stream ecosystems and play a role in nutrient cycling as they process materials from terrestrial and aquatic producers (Wallace and Webster 1996). Macroinvertebrates process detritus, periphyton, and other organic materials in stream ecosystems, and as prey, are a food source for higher trophic levels in streams (e.g. other macroinvertebrates, fish, herpetofauna, birds). Because aquatic macroinvertebrates are confined to the aquatic environment, the presence or absence of certain macroinvertebrate groups can provide insight into stream water quality, especially at local scales. The ease of sampling aquatic macroinvertebrates also adds to their value as a monitoring tool for stream assessments.

No aquatic macroinvertebrate data were available to score condition and trend for Lamberts Run and Grove Run at FLNI. The only aquatic macroinvertebrate data available for Lamberts Run are over 10 years old and represented a sampling location far from FLNI. Aside from the age of the data, Lamberts Run receives AMD inputs at other locations between FLNI and its confluence with the Stoneycreek River, making it impossible to make inferences about aquatic macroinvertebrate communities at FLNI from sampling locations elsewhere in the watershed. However, it is worth

noting that in 2007 and 2008, the SCCD documented a macroinvertebrate community that was tolerant of acidic conditions created by AMD contamination (SCCD 2018). Since 2008, stream water quality metrics in Lamberts Run suggest an overall improvement in stream quality (see previous section on Water Chemistry), and macroinvertebrate communities may have also started to improve.

Data and Methods

No data have been collected for aquatic macroinvertebrates in Lamberts Run or Grove Run at FLNI. There are no methods to report or data to describe.

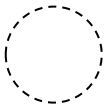
Reference Conditions/Values

Because no data are reported in this section of the NRCA, no benchmarks are described. See Chapter 5 for a discussion of possible monitoring strategies for macroinvertebrates at FLNI, including metrics that can be easily calculated for future assessments of stream quality condition.

Condition and Trend

Since no data have been collected for aquatic macroinvertebrates in Lamberts Run or Grove Run at FLNI, scoring condition or trend is not possible (Table 4-12).

Table 4-12. Condition, trend, and confidence score for aquatic macroinvertebrate data at Flight 93 National Memorial (FLNI), an indicators of stream water quality.

Indicator	Metric	Status and Trend	Rationale and Reference Conditions
Aquatic macroinvertebrates	N/A		• **Condition**: aquatic macroinvertebrates have not been sampled in Lamberts Run or Grove Run at FLNI. • **Trend**: no trend information is available. • **Confidence**: data for this indicator have not been collected in Lamberts Run or Grove Run at FLNI; identified as data gap.

Level of Confidence and Data Gaps

No data have been collected for aquatic macroinvertebrates in Lamberts Run or Grove Run at FLNI.

Community data for aquatic macroinvertebrates constitutes a data gap for FLNI.

Source(s) of Expertise

- Consultation for the status of aquatic macroinvertebrate data for Lamberts Run at FLNI was provided by Pennsylvania Department of Environmental Protection (PA DEP 2018) and Somerset Conservation District (SCCD 2018).

Biological Quality

Birds

Grasslands are one of the dominant natural community types at FLNI. A history of habitat conversion and surface mining have resulted in deforestation, but have created habitat for common grassland bird species, and bird species of conservation importance. Specific threats to grassland bird species and communities at FLNI include certain grassland management techniques, habitat conversion, and natural successional processes. FLNI contains relatively little mature forest and successional forest cover, thus no research has targeted forest interior or forest generalist bird species at FLNI.

Presence of obligate grassland bird species and bird habitat conservation value scores were used as metrics for assessing the condition and trend of the biological quality of the grassland bird community at FLNI. Grassland bird communities and grassland habitat are in good condition at FLNI. Trend could not be scored due to lack of available data. No data exist to evaluate forest generalist or forest interior bird communities.

Indicator Description

Across North America nearly one-third of all grassland bird species are at-risk due to steeply declining populations and threatened habitat, with their continental populations declining by 33% since 1970 (NABCI 2016). Even with a significant amount of non-forested land cover statewide, Pennsylvania grassland birds have experienced severe declines in recent years. Grassland nesting specialists like upland sandpiper (*Bartramia longicauda*) and northern harrier (*Circus cyaneus*) declined significantly in statewide distribution between the 1st Pennsylvania Breeding Bird Atlas (1983–1989) (Brauning 1992) and the 2nd Breeding Bird Atlas (2004–2008) (Wilson et al. 2012) with 57% and 43% declines, respectively.

FLNI falls within a number of geographic regions that are considered important for bird conservation at a landscape scale: the Allegheny Front Important Bird Area (IBA) and the Appalachian Mountains Bird Conservation Region (BCR). Important bird areas are areas that have been identified for their value to breeding, migratory, or over-wintering bird species. The Allegheny Front IBA includes parts of Bedford, Somerset, Cambria, Blair, Centre, and Clearfield counties. Specific conservation targets for this IBA are not available at the time of publication of this report. Bird conservation regions are similar to IBAs but are designated at a larger scale as regions of North America that provide similar ecological conditions, experience similar management challenges, and support similar bird communities (NABCI 2016). The Appalachian Mountains BCR stretches northeast from Alabama to New York. Priority conservation targets within the Appalachian Mountains BCR include cerulean warblers (*Setophaga cerulean*) (lower elevation forests), black-throated blue warbler (*Setophaga caerulescens*) (higher elevation forests), golden-winged warblers (*Vermivora chrysoptera*) (early successional habitats), and Henslow's sparrows (*Ammodramus henslowii*) (grasslands). This BCR also recognizes the importance of headwater (stream) systems that are used by migratory waterfowl, and wetlands for wood duck breeding habitat (NABCI 2016). FLNI is known to support state-listed and SGCN bird species that prefer grassland habitat; including northern harrier (Pennsylvania

Threatened), Henslow's sparrow (candidate Pennsylvania Rare; SGCN species). A full checklist of bird species for FLNI is available in Appendix A.

Changing agricultural practices, habitat loss to development, and insecticide use are among reasons widely cited for grassland bird declines. These are issues in many states including Pennsylvania (Yeany 2018). Climate change is also considered a threat to bird species. Audubon Christmas Bird Count data, collected across the United States, have indicated a shift in the winter ranges of 254 bird species (La Sorte and Thompson 2007). This same analysis suggested the extirpation of one bird species, evening grosbeak (*Coccothraustes vespertinus*), from Pennsylvania (La Sorte and Thompson 2007). Paprocki et al. (2014) also reported a northern shift in the winter range of several bird species.

Data and Methods

Yeany (2019) assessed the conservation value for all potential grassland habitat occupied by 14 grassland bird Species of Greatest Conservation Need (SGCN) in Pennsylvania using a set of four criteria in ArcGIS Pro (Table 4-13). Yeany (2019) used occurrence data for SGCN species collected between 2004–2017. Throughout Pennsylvania, Yeany (2019) identified grassland sites by extracting potential suitable grassland habitat from the 2011 National Land Cover Dataset (NLCD): barren land, shrub/scrub, herbaceous, hay/pasture, and cultivated crops. After combining these landcover classes, grassland patches were aggregated (into patches) using a separation distance of 120m, and each patch was assigned a unique identifier. Grassland bird occurrence data were associated with intersecting (or nearest) grassland habitat patches. Yeany (2019) assigned scores to each grassland habitat patch (site) according to Table 4-13 with each state-listed Threatened or Endangered grassland bird species being given double the weight of other grassland bird SGCN. Larger sites were given higher scores due to area sensitivity of many grassland birds and protected lands were also scored higher (Table 4-13).

Grassland bird communities were assessed at FLNI in 2018 (Yeany 2019). All grassland bird survey locations were placed at a minimum of 400m from each other within grassland habitat and were conducted twice during the height of the avian breeding season, between May 15 and August 15. Breeding status was also determined by documenting behavior for many grassland bird target species, but particularly for high priority target species: short-eared owl (*Asio flammeus*), upland sandpiper, northern harrier, and Henslow's sparrow. For each bird species detected, abundance was calculated for each survey point at FLNI. A full report associated with Yeany's 2018 field-study will be available in late 2019 (Yeany 2019). For this NRCA, the presence of obligate grassland bird species was a valuable metric for scoring condition of the resource.

Table 4-13. Grassland bird site conservation value criteria with scores, weights and maximum total values per site (Yeany 2019).

Criterion Group	Criterion	Score	Weight
Threatened and Endangered Bird Species (max total of group in model = 12)	Dickcissel	1	2
	Loggerhead Shrike	1	2
	Northern Harrier	1	2
	Sedge wren	1	2
	Short-eared Owl	1	2
	Upland sandpiper	1	2
Other Bird Species of Greatest Conservation Need (max total of group in model = 8)	American Kestrel	1	1
	Barn Owl	1	1
	Bobolink	1	1
	Eastern Meadowlark	1	1
	Grasshopper Sparrow	1	1
	Henslow's Sparrow	1	1
	Savannah Sparrow	1	1
	Vesper Sparrow	1	1
Grassland Size in acres (max total of group in model = 5)	> 10000–24670	5	1
	> 1000–10000	4	1
	> 500–1000	3	1
	> 50–500	2	1
	0.22–50	1	1
Protection Status (max total of group in model = 5)	> 50%	5	1
	> 25–50%	3	1
	> 5–25%	1	1
	0–5%	0	1

Reference Conditions/Values

- Grassland habitat benchmarks follow the methodology of ranking sites utilized by Yeany (2019) in his assessment of grassland birds in Pennsylvania.
    - Sites are in good condition if they have a conservation value score of 15 to 22; sites having a conservation value score between 4 and 14 warrant moderate concern, and sites having a conservation value score of 3 or below warrants significant concern.
- Grassland bird communities are considered in good condition if obligate grassland bird species are detected; absence of obligate grassland bird species indicates moderate or significant concern.

Condition and Trend

Based on Yeany's work (2019), FLNI had conservation value scores of 16, indicating grassland bird habitat is in good condition (Table 4-14). Yeany (2019) also detected the presence of obligate grassland bird species at FLNI. Obligate grassland bird species included one state-listed species, northern harrier, two additional species tracked by the PNHP: Henslow's sparrow and vesper sparrow, and five additional species of greatest conservation need (SGCN) (Figure 4-9; Appendix A).

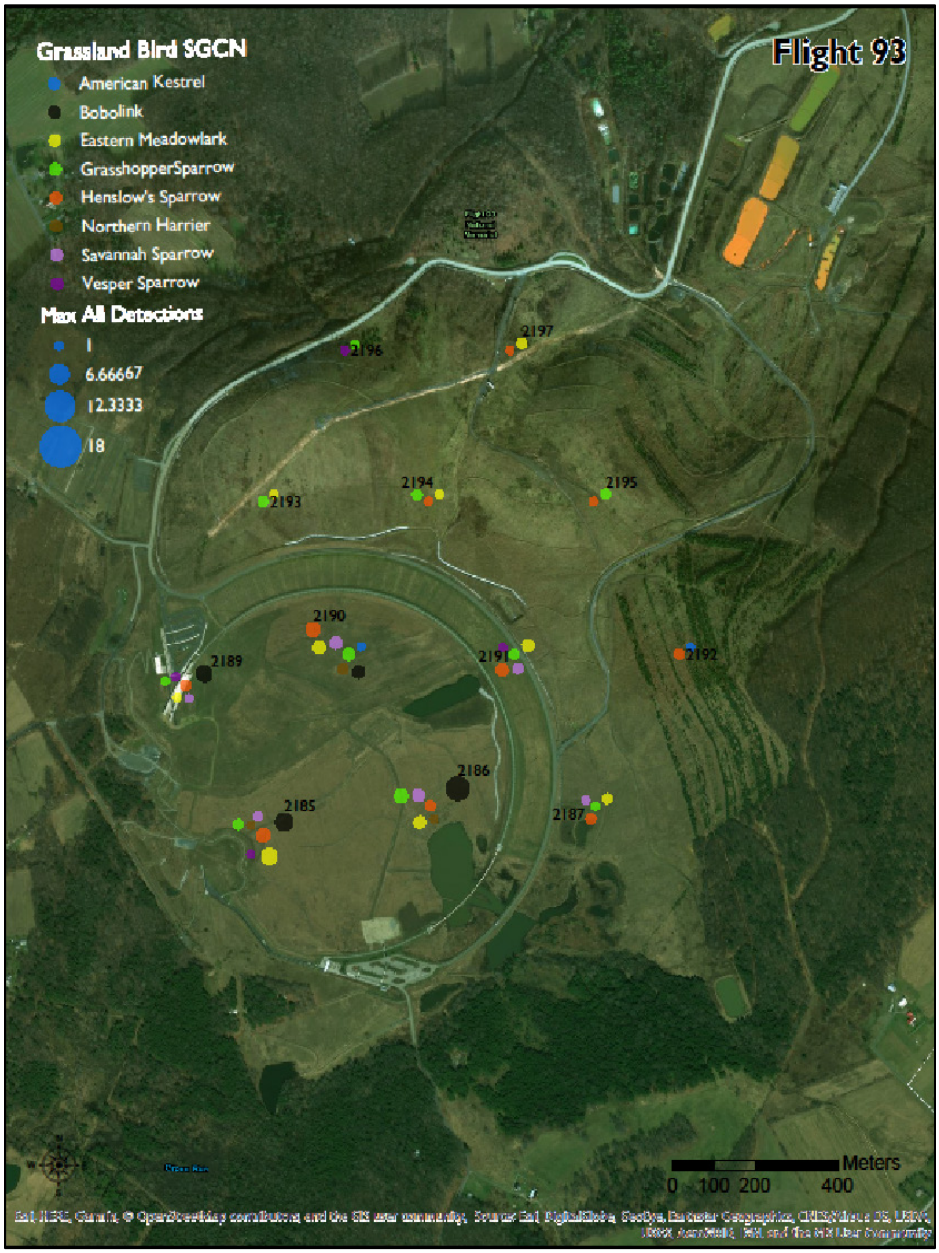
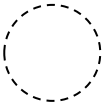
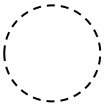


Figure 4-9. Results of Flight 93 National Memorial grassland bird surveys from Yeany (2019). Higher diversity and abundance of obligate grassland bird species were document in habitats with less woody cover, represented by more recently managed habitats among culturally significant features (fields south and west of Memorial Groves).

Table 4-14. Condition, trend, and confidence score for metrics associated with birds, an indicator of biological quality at Flight 93 National Memorial (FLNI).

Indicator	Metric	Status and Trend	Rationale and Reference Conditions
Grassland birds	Presence of obligate grassland bird species		• **Condition**: Grassland-obligate bird species were detected at FLNI. • **Trend**: based on available data, scoring trend was not possible. • **Confidence**: confidence is high; data were collected on-site, and multiple site visits were performed in a single field-season (2018).
Grassland bird habitat	Conservation value score (Yeany 2019; remote sensing)		• **Condition**: FLNI had a conservation value score of 16; based on remote sensing data, grassland bird habitat was scored as good condition. • **Trend**: based on available data, scoring trend was not possible. • **Confidence**: confidence is medium; data were based on remote sensing (national land cover data).
Forest generalist bird community	N/A		• **Condition:** data exist; could not be scored. • **Trend**: data exist; could not be scored. • **Confidence**: data exist; low confidence.
Forest interior bird community	N/A		• **Condition:** data exist; could not be scored. • **Trend**: data exist; could not be scored. • **Confidence**: data exist; low confidence.

Level of Confidence and Data Gaps

Confidence is medium for grassland bird habitat data. Yeany's (2019) model considered on-site conditions for general habitat type using the NLCD, and local information on state-listed and SGCN bird species. However, site scores were largely based on NLCD (2011), and a confidence value of medium is also consistent with other NRCA metrics that use remote sensing data. Although vegetation data from Yeany (2019) could not be scored for the FLNI NRCA, these data indicated variation in quality of early successional habitats at FLNI. This also reduces confidence in the initial scoring. Obligate grassland bird species were detected at FLNI, and some high-quality grassland sites exist at FLNI. Yeany (2019) detected variation in habitat suitability for obligate grassland birds and detected a difference in obligate grassland bird species abundance between grasslands and shrubland habitats. A comprehensive, quantitative sampling of all early successional (grasslands and shrublands), where the cover of shrubs and other woody vegetation are estimated, would provide a more representative assessment of grassland habitat condition at FLNI (on-site vs remote sensing data). Trend could not be scored (Table 4-14). Site visits were only performed during a single field season, and no other data on grassland habitat quality had been collected previously at FLNI.

Confidence is high for detection of grassland-obligate bird species. Data were collected on site, and multiple site visits were conducted during the 2018 breeding season. Trend could not be scored since site visits were only performed during a single field season in 2018, and no other data on obligate grassland bird species had been collected at FLNI prior to Yeany (2019).

No data exist to score forest interior or forest generalist bird communities.

Source(s) of Expertise

- Yeany (2019) provided data and methods for grassland bird surveys that were conducted at FLNI in 2018. The manuscript for this project was still in preparation as the FLNI NRCA was being constructed.

- The 2018 field work done by the WPC provided on-site data and map validation for select natural communities and successional types at FLNI.

Pollinators

Presence of cleptoparasitic guild was used as a metric for the biological quality of pollinators. As an important component of the pollinator community, bee species are in good condition at FLNI. Pollinator trend could not be determined due to insufficient data. Data is lacking for other pollinator species at FLNI. The good health of the bee community at FLNI may be explained by limited insecticide use at FLNI (Kautz et al. 2018).

Indicator Description

Pollinators provide a valuable service for agriculture (P4 Task Force 2018). In a 2014 White House Fact Sheet, it was suggested that pollinators contribute 24 billion dollars to the economy in the United States (The White House 2014). Enhanced pollination can benefit agriculture in a number of ways, such as increasing seed production, or enhancing production of edible portions of fruits, nuts, and vegetables (P4 Task Force 2018). The P4 Task Force (2018) suggests that Pennsylvania has a diverse agricultural economy relative to other states in the U.S., with only New York and California having greater crop diversity than Pennsylvania. Animals pollinate a large number of flowering plants in temperate ecosystems (78%; Ollerton et al. 2011), which is integral for maintaining plant diversity. While other insects, such as flies, butterflies, moths, and beetles may be important for pollination in Pennsylvania, bees have received greater research attention in an agricultural context. At FLNI, Powdermill Nature Reserve (PNR) conducted an assessment of the bee community in 2016 and 2017 (Kautz et al. 2018). No other research into pollinator communities (butterflies, moths, other insects) has been conducted at FLNI.

Threats to pollinators include habitat loss and fragmentation that result from land-use change, pesticide use, and pathogens and pests (P4 Task Force). FLNI has experienced significant disturbance in the past century due to surface mining. However, the current state of revegetation of these previously disturbed areas provides good habitat for bees and other pollinators at FLNI. Management of early successional habitats may pose the most significant threat to native pollinator communities at FLNI. Mowing too frequently or failure to provide refugia for pollinators, could

reduce the number of flowering plants that serve as a nectar source for pollinators. Bees have received research attention at FLNI and were chosen as an indicator of Biological Quality at FLNI.

Data and Methods

Inventory and snap shot sampling of bee diversity were conducted at FLNI in 2016 and 2017 (Kautz et al. 2018). Although the researchers deployed different sampling strategies over the duration of the study, results were similar in each year of sampling indicating that the less time intensive method (i.e. snap shot method) should be sufficient for assessing diversity in future projects. A complete list of bee species documented at FLNI is available in Appendix B. Sheffield et al. (2013) suggested the relative abundance of cleptoparasitic (parasitic) bees can be used as an indicator of community health. Wenzel (personal communication, 2018) also suggests that the presence of parasitic bees is informative when assessing bee community quality. However, specific benchmarks for cleptoparasitic bee diversity and relative abundance as indicators of community quality have not been established.

Reference Conditions/Values

- Bee communities are considered in good condition if cleptoparasitic guilds are detected. Absence of a cleptoparasitic guild warrants moderate or significant concern.

Condition and Trend

The bee community at FLNI is in good condition based on the detection of cleptoparasitic bees by Kautz et al. (2018) (Table 4-15). Kautz et al. (2018) documented levels of diversity and relative abundance of parasitic bees at FLNI comparable to the bee community at PNR, a protected area within the same region as FLNI with a good bee community (Wenzel, personal communication 2018). The presence of a cleptoparasitic bee community at FLNI also suggests a healthy (overall) bee community (Wenzel, personal communication 2018). There are no established benchmarks to score the condition of the cleptoparasitic bee community beyond presence/absence. Furthermore, at the time of preparation of this NRCA, quantitative data for the bee community (number of individuals of each species) were not available for FLNI samples. Scoring trend was also not possible; data from Kautz et al. (2018) are the only pollinator/bee data that have been collected to date at FLNI.

Table 4-15. Condition, trend, and confidence score for the metric associated with bees, an indicator of Biological Quality at Flight 93 National Memorial (FLNI).

Indicator	Metric	Status and Trend	Rationale and Reference Conditions
Bee community quality	Presence of cleptoparasitic guild		**Condition**: Kautz et al. (2018) documented the presence of a cleptoparasitic guild at FLNI; Wenzel (personal com.); indicator in good condition. **Trend**: no scoring of trend was possible. **Confidence**: medium confidence; presence/absence indicator, more definitive scoring of condition not possible based on available science.

Level of Confidence and Data Gaps

Pollinator (bee community) data have been collected on-site. However, without established benchmarks to apply to bee community data or access to raw data for the FLNI bee community, confidence is medium. More bee community sampling is needed to evaluate trend in bee community quality at FLNI. Other pollinator communities exist at FLNI and should be studied more intensively to provide a comprehensive profile of pollinator habitats and pollinator community condition at FLNI.

Source(s) of Expertise

- PNR provided bee community data and suggestions for bee community indicators/metrics of quality.

Mammals

Condition and trend could not be scored for mammals at FLNI. Except for bats, no mammal data have been collected at FLNI. The bat data is informative about the species of bats using FLNI but is based on very limited sampling in which there are no metrics to score.

Indicator Description

The Western Pennsylvania Conservancy (WPC) created a list of mammal species along with a categorical rank for the probability of occurrence for each species at FLNI (see Appendix C) (WPC 2005). Beyond this, a comprehensive mammal inventory has not been conducted for FLNI. However, more focused work has been done on bats as part of a multi-park survey for the species (Nagel and Gates 2018).

Southwestern PA, where FLNI is found, encompasses the ranges of 11 bat species, including several state and federally listed bat species (Merritt 1987, Kurta 1995, Whitaker and Hamilton 1998, Harvey et al. 1999, Nagel and Gates 2018). Bats represent the second largest order of mammals and provide important ecosystem services (Barbour and Davis 1969). Those services include supporting cave communities, insect control, pollinators, and seed dispersal (NPS 2018). Unfortunately, bats are declining rapidly in North America. Habitat loss, wind energy development, and white-nose syndrome (WNS) are all threats contributing to the decline of the species. WNS is the most serious threat of them all and predominantly affects hibernating bats. WNS has been found in bat hibernaculum throughout all of Pennsylvania along with most of the eastern United States and Canada (PGC 2019). It is estimated that millions of bats have died from WNS (USFWS 2019). Though populations of some bat species have suffered massive declines, limited numbers of resilient survivors have been found. The hope is that their offspring will be able to do the same. Conservation measures are now aimed at the protection of maternity colonies, so that more offspring might survive and increase bat populations.

Data and Methods

A single bat survey was conducted at FLNI in 2015 by Nagel and Gates (2018). This survey was part of a larger effort to inventory bats at NPS units in southwestern Pennsylvania. Those Parks included in this effort were FLNI, FONE, JOFL, ALPO, and FRHI. At FLNI, a combination of captures (mist-nets) at 5 sites and acoustic recordings (ultrasonic receiver) at 3 sites were used to survey for bats

(see Nagel and Gates for specific details on methods used). Sampling sites were chosen based on the high probablity of capturing or detecting bats (e.g. near ponds and the stream towards the southern end of the Memorial). Sampling occurred over a period of three days. Four bat species were identified using these combined survey methods and included eastern red bat (*Lasiurus borealis*), hoary bat (*Lasiurus cinereus*), big brown bat (*Eptescicus fuscus*), and potentially silver-haired bat (*Lasionycteris notivagans*) (Table 4-16). Acoustic counts for big brown bat and silver-haired bat were combined because it is difficult to distinguish their calls from one another (Nagel and Gates 2018). The Nagel and Gates (2018) study is the only source of bat data available for FLNI.

Table 4-16. Summary of bat data by method collected in 2015 for Flight 93 National Memorial. Source of data from Nagel and Gates (2018). Bat abbreviations are as follows: NOID = Unidentifiable bat call; LACI = hoary bat; EPFU = big brown bat; EPFU/LANO = big brown bat/silver haired bat; LABO = eastern red bat.

Method	NOID	LACI	EPFU	EPFU/LANO	LABO	TOTAL
Captures	0	0	3	0	1	3
Acoustic	2	1	0	16	0	19

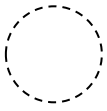
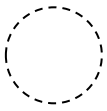
Reference Conditions/Values

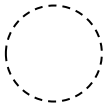
There are no established reference conditions to score captures (average bats captured) or acoustic results (average number of bat echolocation).

Condition and Trend

Condition and trend were not scorable from FLNI bat data. Bat data available from Nagle and Gates (2018) were not suitable for reliably scoring the condition for bats at FLNI (Table 4-17). Furthermore, there are no established reference conditions to score the metrics of average bats captured for per unit effort or average number of bat echolocation passes per minute. Although data from Nagle and Gates (2018) could not be used to provide a condition score or trend for bats at FLNI, their results provide baseline data for FLNI.

Table 4-17. Condition, trend, and confidence score for metrics associated with mammals, which are indicators of biological quality at Flight 93 National Memorial (FLNI).

Indicator	Metric	Status and Trend	Rationale and Reference Conditions
Bats	Average bats captured per unit effort		• **Condition**: no condition could be derived from available data. • **Trend**: no trend data available. • **Confidence**: no data available.
	Average bat echolocation passes per minute		• **Condition**: no condition could be derived from available data. • **Trend**: no trend data available. • **Confidence**: no data available

Indicator	Metric	Status and Trend	Rationale and Reference Conditions
Other mammals	N/A		• **Condition**: no data for other mammal species exist for FLNI; no condition could be derived from available data. • **Trend**: no data for other mammal species exist for FLNI; no trend data available. • **Confidence** no data for other mammal species exist for FLNI; no data available for non-bat mammals at FLNI.

Level of Confidence and Data Gaps

Even though a condition score could not be derived from available data for bats, data have been scored as high confidence to reflect bat survey effort at FLNI. High confidence data without a condition score reflect the presence of species at FLNI. The presence of these species could be used as a rationale for future monitoring of bats at FLNI. Additional future mammal work should be done since this information is lacking for FLNI.

Source(s) of Expertise

- Bat survey data for FLNI was provided by Nagle and Gates (2018). Consultation for reference conditions to score bat data were provided by NPS-I&M.

- List of mammal species that could potentially occupy FLNI were provided by WPC (2005).

Herpetofauna and Fish

Condition and trend could not be scored for herpetofauna (reptiles and amphibians) and fish at FLNI because sufficient data is not available for FLNI. The WPC (2005) created a list of reptile species (see Appendix D), along with a categorical rank for the probably of occurrence for each species, that could occur at FLNI. However, a formal inventory of reptiles, amphibians, and fish have not been conducted for FLNI.

Indicator Description

No data were available that allowed for scoring of condition, trend or confidence for herpetofauna and fish. Herpetofauna and fish should be the target of future natural resource inventory work at FLNI.

Data and Methods

No data have been collected for herpetofauna or fish at FLNI; there are no methods to report or data to describe.

Reference Conditions/Values

Because no data are reported in this section of the NRCA, no benchmarks were described. See Chapter 5 for a discussion of possible monitoring strategies for herpetofauna and fish at FLNI.

Condition and Trend

No data have been collected for aquatic herpetofauna or fish at FLNI. Scoring condition or trend for is not possible (Table 4-18).

Table 4-18. Condition, trend, and confidence score for metrics associated with herpetofauna and fish, indicators of biological quality at Flight 93 National Memorial.

Indicator	Metric	Status and Trend	Rationale and Reference Conditions
Reptiles	N/A		No information currently available to determine condition and trend.
Amphibians	N/A		No information currently available to determine condition and trend.
Fish	N/A		No information currently available to determine condition and trend.

Level of Confidence and Data Gaps

No data have been collected for aquatic herpetofauna or fish at FLNI. Scoring of confidence is not possible.

Species inventory and habitat quality data for herpetofauna and fish constitute data gaps for FLNI.

Source(s) of Expertise

- The WPC (2005) provided a list of reptile species that could occur at FLNI.

Ecological Quality

Natural Communities

Twenty-two plant communities were identified, mapped, and described at FLNI; nine natural community types (seven upland and 2 wetland), nine successional or modified (managed) types, and four non-natural types (highly disturbed and/or permanently modified features typically not supporting vegetation). A Landscape Condition Model (LCM) for Pennsylvania (PNHP 2016) was used to assign landscape condition scores to the different plant community types. The scores were then used as the metric to assess the condition of plant communities at FLNI from a landscape perspective relative to nearby anthropogenic disturbance. Plant community data for FLNI was used to estimate the cover of native plant species in each community type which was then used as the metric to score the condition of plant community composition. The condition of natural and successional communities at FLNI varies considerably across FLNI and reflects a variety of intense historical human uses including strip mining, logging, and farming.

Indicator Description

Pennsylvania's plant community classification (Fike 1999, Zimmerman et al. 2012) has been vitally important to the mapping of natural communities on public lands. The Pennsylvania classification has evolved over the past 30 years and continues to improve the ability of users to accurately map natural communities across the Commonwealth. Quite often, a map of natural communities can form the basis of natural resource management or conservation-focused monitoring programs, providing baseline data to study community change over time. Natural communities and other features were mapped at FLNI in 2005 (see WPC 2005, Appendix E). The landscape at FLNI is dominated by successional plant communities, most of which are the result of surface mining and mine reclamation practices. However, successional habitats provide valuable habitat for wildlife, including species of conservation value. Northern harrier, a state-listed bird species, along with many bird species of greatest conservation need, have been documented in grassland habitat at FLNI (see 4.5.1).

Invasive plants and insects are a significant threat to both natural and successional communities at FLNI. Many communities at FLNI are early to mid-successional, and although successional, these communities have the potential to support diverse flora and fauna. Unfortunately, the same conditions that can facilitate native species diversity can also facilitate the establishment of invasive plant species (e.g. recent disturbance, open conditions, exposed soils). The majority of successional habitats at FLNI are managed meadows, or unmanaged meadows and shrublands. While the transition from herbaceous to grass-dominated meadows to shrublands or woodlands would be expected at FLNI, natural successional processes can be interrupted by invasive plant species. Invasive plants are common at FLNI and easily dispersed into the more natural communities at FLNI. The majority of woodland and forest communities at FLNI are also successional and contain invasive plant species. Invasive species in forest communities can inhibit regeneration of native tree species, which has long-term consequences for managing forest communities at any scale.

Hemlock wooly adelgid (HWA), an invasive insect, is a major threat to the forest landscape. HWA has been documented in the Hemlock Grove (a culturally significant area), and this area has received

significant management attention (Turcotte et al. 2012). A loss of hemlock would drastically change the Hemlock (white pine) forest and Hemlock (white pine) – northern hardwood forests at FLNI.

Threats to natural communities also include climate change. Gonzales et al (2018) projects that FLNI could experience an increase in precipitation as a result of climate change and may also experience an increase in the frequency of extreme storm events. Soils at FLNI may already be compacted as a result of surface mine reclamation. Soil compaction can reduce the ability for water to infiltrate into soils, resulting in greater surface runoff, and soil erosion. Erosion not only impacts stream water quality, but can reduce soil quality, and the ability of soils to support native species. Gonzales et al. (2018) also projects that FLNI could experience an increase in temperature as a result of climate change. Iverson et al. (2008) have modeled that the range of a number of native tree species in the eastern United States could be impacted by climate change (see also Gonzales et al. 2018). At FLNI, these species include (but are not limited to) black cherry (*Prunus serotina*) and oaks (*Quercus* spp.), which are common throughout the site.

Data and Methods

For the NRCA, the WPC mapped and described all-natural communities and successional cover types at FLNI using aerial photography (Figure 2-10). Culturally significant landscapes were also mapped. The WPC used the existing cover type mapping from WPC (2005) as a reference. However, the plant communities and successional cover types at FLNI were redetermined to reflect changes to the landscape that have occured since the parks establishment (i.e. construction of the visitor's center, amenities, other culturally significant features constructed at the Memorial). New mapping also reflects changes to the Pennsylvania community classification for wetland communities (Zimmerman et al. 2012).

Ecologists from the WPC performed site visits in October 2018 to validate composition for a number of natural communtities and culturally signficant features. In select natural communties and successional types, the WPC documented dominant species in the canopy, shrub layer, and herbaceous layer. Rapid assessments of natural community vegetation, conducted as part of the grassland bird study from Yeany (2019), were also used to validate and modify spatial data for FLNI. Yeany (2019) documented dominant plant species in each strata (canopy, understory, tall shrub (2–5m), short shrub (0.5–2m), and herbaceous). Height of each strata was also visually estimated by Yeany (2019), as was the overall cover of each strata. These estimates are useful in classifying communities as forests, woodlands, shrublands, or herbaceous dominated communities and routinely used in collecting community classification data.

Marconi and Knee (2013) provided data for invasive species at FLNI, but surveys were restricted to early succcessional habitats. Observations from Marconi and Knee (2013) for invasive species presence in these habitats were consistent with the observations from Yeany (2019).

A landscape condition model (LCM) was developed by PNHP (2016) to assess landscape context of landscape features of conservation interest using methods developed by NatureServe (Comer and Hak 2014). An LCM may be used to obtain a rough estimate of landscape condition based on the presence and proximity to anthropogenic disturbance and is often used as a "Level 1 assessment," or

rapid estimate of ecological integrity (see Faber-Langendoen et al. 2016). Condition scores from the Pennsylvania LCM (PNHP 2016) were summarized for all delineated patches of natural and successional vegetation and Culturally Significant Features at FLNI (Table 4-19, Figure 4-10).

Table 4-19. Landscape Condition Model (LCM) results (PNHP 2016) summarized by natural and successional plant community types at Flight 93 National Memorial (FLNI).

Community Type	LCM Min	LCM Max	LCM Mean	Standard Deviation
Black cherry – northern hardwood forests	0.92	1.00	0.96	0.04
Cat-tail marsh	0.68	0.86	0.77	0.04
Hemlock (white pine) – northern hardwood forest	0.67	1.00	0.91	0.09
Hemlock (white pine) forest	0.76	1.00	0.92	0.06
Northern hardwood forest	0.71	0.97	0.87	0.05
Red maple (terrestrial) forest	0.66	1.00	0.92	0.06
Red maple – black gum palustrine forest	0.78	1.00	0.95	0.06
Black locust forest	0.69	0.92	0.82	0.06
Conifer plantation	0.69	0.71	0.70	0.01
Successional forest	0.54	1.00	0.84	0.09
Successional woodland	0.58	1.00	0.85	0.10
Successional shrubland	0.78	1.00	0.92	0.07
Modified terrestrial herbaceous habitat	0.54	1.00	0.82	0.09
Modified palustrine / floodplain herbaceous habitat	0.67	1.00	0.88	0.11

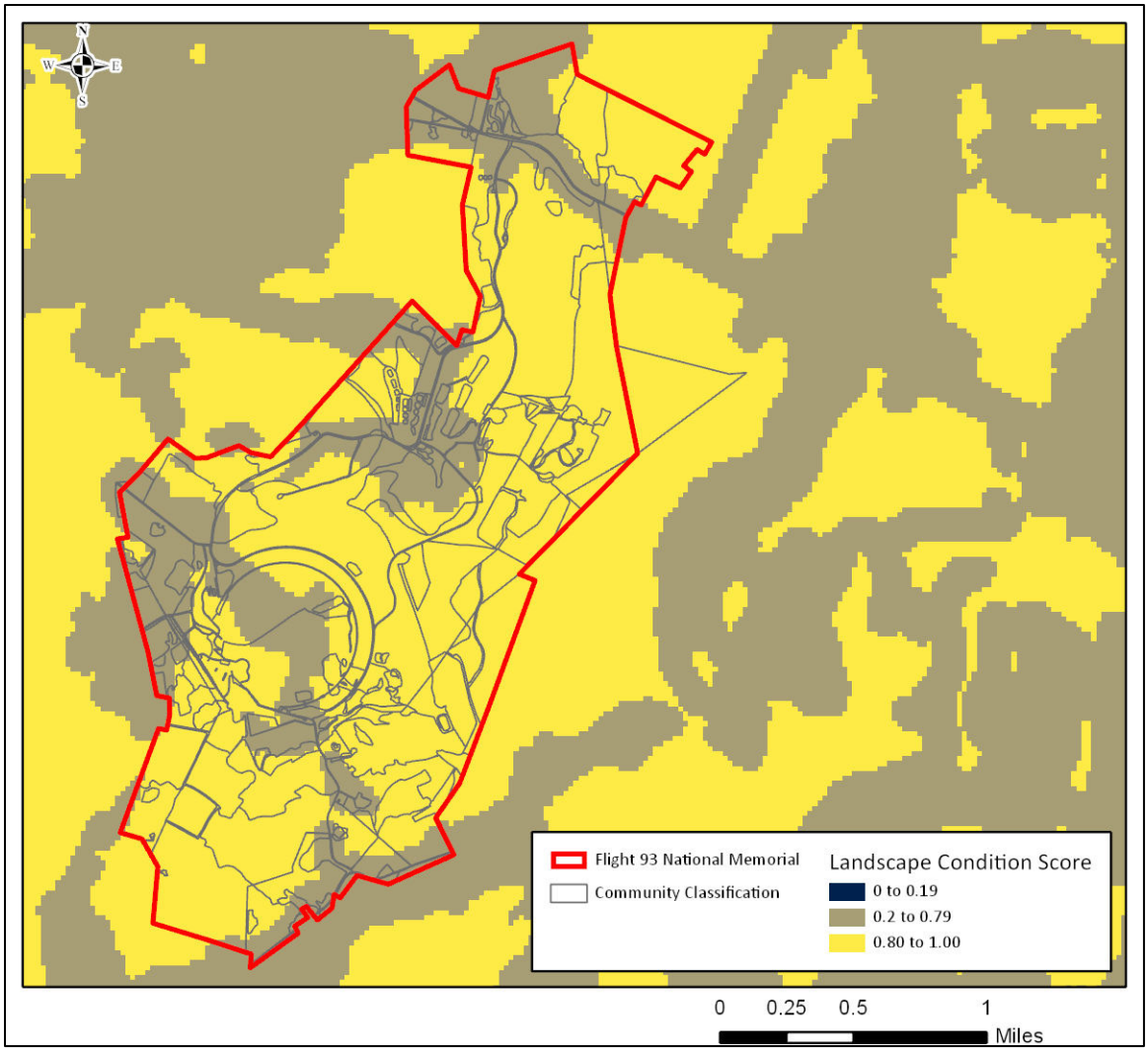


Figure 4-10. Landscape condition scores by cover type and categorized according to scoring criteria for the Flight 93 National Memorial Natural Resource Condition Assessment (NRCA). Data for Flight 93 National Memorial were extracted from the Landscape Condition Model from the Pennsylvania Natural Heritage Program (PNHP) (2016).

In conducting work for this NRCA, the WPC documented nine natural community types at FLNI (Figure 2-10). These types correspond to the Pennsylvania plant community classification and include seven upland types and two wetland community types. The WPC also documented nine successional or modified (managed) types at FLNI. Successional forests were classified using aerial photography. Successional forests showed evidence of current or past disturbance, and the composition could not be determined using available data (WPC 2005, Yeany 2019; field surveys associated with this NRCA). One area was typed as Maintained lawn; this type was applied to the Memorial groves and represents a community type that has heavily modified and managed. No additional description is provided for Successional forests or Maintained lawns. The Memorial groves are discussed in greater detail in section 4.6.2.

The WPC also identified four non-natural types, which are highly disturbed and/or permanently modified features that typically support no vegetation. These included roads, developed areas, parking areas, and cleared land. Developed areas also included park buildings or paved areas associated with culturally significant features. Cleared land included riprap associated with drainage areas, or disturbed soils that lack vegetation. Non-natural features are not discussed in detail below.

The following information pertains to natural communities documented at FLNI, and descriptions were derived from site visits associated with this NRCA (fall 2018; descriptions limited to vegetation present in fall 2018):

Black cherry – northern hardwood forest: This upland community type was documented in a single location along the eastern boundary of the FLNI. This community type was dominated by black cherry (*Prunus serotina*) and red maple (*Acer rubrum*), and also included sugar maple (*Acer saccharum*), hickory (*Carya* spp.), and white oak (*Quercus alba*). At FLNI, Black cherry – northern hardwood forests were similar to Red maple (terrestrial) forests but had a higher relative cover by black cherry than red maple or other hardwoods. Common shrubs included witch-hazel (*Hamamelis virginiana*), and common species in the herbaceous layer included spinulose wood fern (*Dryopteris carthusiana*), bellwort (*Uvularia* spp.), Canada mayflower (*Maianthemum canadense*), and hayscented fern (*Dennstaedtia punctilobula*).

Cat-tail marsh: This wetland community type was documented downstream of AMD treatment infrastructure near Lamberts Run (western boundary of FLNI). Cat-tail (*Typha latifolia*) dominates this wetland, and many standing dead trees were noted in the wetland. Red maple was documented along the margins of this wetland, along with other disturbance tolerant forest species (trembling aspen, *Populus tremuloides*).

Hemlock (white pine) – northern hardwood forest: This upland community type occurs at the southern end of FLNI and contains the majority of species that are described as dominant or diagnostic in the Pennsylvania plant community classification. The Hemlock (white pine) – northern hardwood forest is significant at FLNI, as this type is associated with the Hemlock Grove, a culturally significant feature (see 4.5.2). Hemlock (*Tsuga canadensis*) is co-dominant with sweet birch (*Betula lenta*), yellow birch (*B. allegheniensis*), and beech (*Fagus americana*). Red maple and trembling aspen were also encountered in this community type and are probably reflective of historic disturbance in these forests. Common species in the shrub layer included regenerating hemlock and beech, and common species in the herb layer were spinulose wood fern (*Dryopteris cathusiana*), indian cucumber root (*Medeola virginiana*), and Canada mayflower (*Maianthemum canadense*). Hayscented fern (*Dennstaedtia punctilobula*) also occurred in this type and was often associated with canopy gaps in dry soils.

Hemlock (white-pine) forest: This upland community type is found in the southern end of FLNI and is species poor. Like the Hemlock (white pine) – northern hardwood forest, the Hemlock (white pine) forest at FLNI contains the majority of species that are described as dominant or diagnostic in the Pennsylvania plant community classification. This type occurred along Grove Run and was adjacent to pastureland (typed as Modified terrestrial herbaceous habitat in Figure 2-10). The canopy is

dominated by hemlock and white pine (*Pinus strobus*). Shrubs and herbs were sparse in this community type.

Northern hardwood forest: This type was documented in the far north and southern reaches of FLNI. No site-specific data are available for Northern hardwood forests at FLNI. Based on the hardwood composition of other forested communities and WPC's experience with hardwood dominated stands in the Central Appalachian forests, the Northern hardwood forest type at FLNI is likely dominated by a mix of beech, red maple, and yellow birch. Birch and beech regeneration can be patchy at times, but shrub cover is generally low in the absence of invasive species. Spinulose wood fern, intermediate woodfern (*Dryopteris intermedia*), christmas fern (*Polystichum acrostichoides*), hayscented fern, and/or New York fern (*Thelypteris noveboracensis*) may all be present in this community type.

Red maple – black-gum palustrine forest: This wetland community type occurred in a single location at FLNI. Common tree species include red maple, black-gum (*Nyssa sylvatica*), yellow birch, hemlock, and hawthorn (*Crataegus* spp.). Other notable species in this type included viburnum (*Viburnum* spp.), cinnamon fern (*Osmunda cinnamomea*), woolgrass (*Scirpus cyperinus*), swamp dewberry (*Rubus hispidus*) and sensitive fern (*Onoclea sensibilis*).

Red maple (terrestrial) forest: This upland community type was documented throughout FLNI, and rarely formed mature forests. Common tree species included red maple, sweet birch, and black cherry. White pine was documented in this community type, but this species was typically found near forest edges, and could be present as a result of historic mine reclamation (planting, or seed dispersal from reclamation planting). Common shrubs included witch-hazel and hawthorn, and common herbs included sedges (*Carex* spp.), crowsfoot (*Diphasiastrum digitatum*), Canada mayflower, and hayscented fern. Along the eastern boundary of FLNI, very early successional versions of this type were documented; these stands were dominated by regenerating red maple and sweet birch, and shrub and herb cover appeared to be low.

Red oak – mixed hardwood forest: This upland community type was uncommon at FLNI. Dominant tree species included red oak (*Quercus rubra*) and red maple, but hemlock, sugar maple, chestnut oak (*Quercus montana*), and beech were also present. Shrubs included witch-hazel, *Rubus* spp., and hillside blueberry (*Vaccinium pallidum*). Herbs included Christmas fern, violets (*Viola spp.*), spinulose wood fern, partridge berry (*Mitchella repens*), and Indian cucumber root. This was one of the least disturbed forest community types at FLNI, occurring along the eastern boundary of the park.

Black locust forest: This upland community type is recognized by the Pennsylvania plant community classification, but is often related to highly successional landscapes, and is therefore unpredictable in its species composition or dominance. Dominant species often include black locust (*Robinia pseudoacacia*). This type was not visited by WPC in 2018, but the Successional woodland and Successional shrubland types described below (from Yeany 2019) may share many of the same species and structural characteristics with the Black locust forest type.

Successional woodland: This upland type was located in early successional areas of FLNI that are likely associated with historic surface mine reclamation. This type contains approximately 25% cover from tree species that are greater than 5m tall. Common tree species include black locust, quaking aspen, and black cherry in the canopy, and honeysuckle (*Lonicera* sp.) and raspberry (*Rubus* sp.) in the shrub layer. In addition to non-native honeysuckle, other invasive species that were commonly encountered in this type include tree-of-heaven (*Ailanthus altissima*) and autumn olive (*Elaeagnus umbellata*). Species introduced as part of mine reclamation (not associated with Tyree et al. 2018) include red pine (*Pinus resinosa*), scots pine (*Pinus sylvestris*) and spruce (*Picea* sp.).

Modified terrestrial herbaceous habitat: At FLNI, this upland type can be dominated by herbaceous or graminoid species. These two forms cannot be distinguished from each other using aerial photography. Because Yeany (2019) only studied select early successional habitats at FLNI, and to ensure consistency in typing of early successional habitats that were delineated using aerial photography, Yeany's (2019) Herbaceous meadow and Standing hayfield type were combined in this NRCA. Low shrub cover was observed in this type (Yeany 2019). Dominant species included Canada goldenrod (*Solidago canadensis*) and common milkweed (*Asclepias syriaca*). Other common invasive species included asters (*Symphyotrichum* spp.), fleabane (*Erigeron* spp.), goldenrod (*Solidago* spp.) and wild carrot (*Daucus carota*). Some areas typed as Modified terrestrial herbaceous habitat have been seeded with a wildflower mix by NPS; common species in including sunflowers (*Heliopsis* spp.), bee balm (*Monarda* spp.) and blazing stars (*Liatris* spp.). If shrubs were present, they were often non-native species, such as honeysuckle (*Lonicera* spp.). Graminoid-dominated habitats were associated with mine reclamation and had lower relative cover from herbaceous species than Yeany's (2019) Herbaceous meadow. Common species in graminoid-dominated habitats included tall fescue (*Schedonorus arundinaceus*), smooth brome (*Bromus inermis*), orchard grass (*Dactylis glomerata*), big blue stem (*Andropogon gerardii*) switchgrass (*Panicum virgatum*), and Kentucky bluegrass (*Poa pratensis*). Although sparse, herbaceous species include clover (*Trifolium* sp.) and bird's-foot trefoil (*Lotus corniculatus*).

Modified palustrine / floodplain herbaceous habitat: This wetland type is associated with created wetlands FLNI; Yeany (2019) referred to this type as Herbaceous wetland. This type always supports obligate wetland species and can be dominated by native or non-native species. When native plant species dominated, this type can be dominated by a variety of sedge (*Carex* spp.), rush (*Juncus* spp.), and bulrush species (*Scirpus* spp.). Pockets of standing water or mud are common. This type can may also have a shrub component, but herbaceous or graminoid species dominate at FLNI. The invaded subtype is dominated by reed canary grass (*Phalaris arundinacea*) and cattail (*Typha* sp.), with nearly 100% cover of these two species and a low species diversity overall.

Successional shrubland: This upland type is associated with reclaimed habitat at FLNI. The Successional shrubland has at least 25% cover from woody species that are less than 5m tall. In some areas, planted conifers such as red pine, scots pine, and spruce may be present. More often, the dominant woody species in Successional shrublands are invasive species such as autumn olive and non-native honeysuckle. Black locust and raspberry (*Rubus* spp.) were also documented in this type at FLNI. Common graminoid species include tall fescue, smooth brome and orchard grass. Clover

(*Trifolium* spp.) and goldenrod (*Solidago* spp.) were very common in the herbaceous layer of Successional Shrublands.

Conifer plantation: This upland type was documented in a single location within the proclamation boundary, north of Route 30. This type was documented by WPC (2005) and was not visited during site visits for the FLNI NRCA, or by Yeany (2019). Composition of this community type is unknown, but aerial photography suggests this classification is appropriate.

Landscape condition scores from the Pennsylvania LCM (PNHP 2016) were summarized for all cover classes (including natural communities and successional/cultural vegetation cover) at FLNI (Table 4-19, Figure 4-10). An LCM (Comer and Hak 2014) may be used to obtain a rough estimate of landscape condition based on the presence and proximity to anthropogenic disturbance and is often used as a "Level 1 assessment," or rapid estimate of ecological integrity (see Faber-Langendoen et al. 2016).

Reference Conditions/Values

All delineated natural community and successional land cover patches were evaluated to determine Ecosystem Quality values for FLNI using the Pennsylvania LCM (PNHP 2016) for general landscape context. Information from field activities presented in WPC 2005, Yeany 2019, and rapid field visits performed in 2018 by WPC were used to help determine the condition of plant composition of community types at FLNI. A field-based systematic evaluation of ecological integrity of vegetation communities (e.g. Perles et al. 2010, Comiskey and Wakamiya 2011) has not been conducted at FLNI. Therefore, the current conditions and trends relied on existing community classification information from a property evaluation by the WPC (2005) prior to the establishment of FLNI and recent evaluation of the grassland bird habitat (Yeany 2019). Rapid field evaluations were conducted as part of this project to validate updated vegetative cover mapping activities. Rapid field assessments were conducted by WPC using traditional Natural Heritage methodology for evaluating plant community occurrences (NatureServe 2002), which uses landscape context and condition to rank occurrences from A-D. Landscape context and condition are measures of ecological integrity of a landscape unit, which evaluates the "outer workings" (context) and "inner workings" (condition) of an ecosystem (Faber-Langendoen et al. 2016). A good landscape condition score suggests that the feature exists in a continuous/connected landscape that supports all requirements needed to sustain native ecosystems and ecological processes. Additional rapid evaluation techniques can be found in (Faber-Langendoen et al. 2012, 2016, Rocchio and Crawford 2009). Results of all evaluations are summarized in this section and include the following:

- Landscape context condition: LCM scores were used as the metric for each natural community and successional cover type patch; scores reflect presence and proximity to anthropogenic disturbance. The LCM for Pennsylvania (PNHP 2016) utilizes remotely sensed data and often scores reclaimed mined lands similarly to native grasslands. Therefore, scores may not completely reflect the ecological condition of natural communities and successional types at FLNI.

- Natural Forest Communities – Good landscape condition: LCM > 0.8; Moderate Concern: LCM = 0.2–0.8; Significant Concern: LCM <0.2

- Successional forest, woodland, shrubland, and all wetland communities/cover types - Good landscape condition: LCM > 0.8, landscape/soils not modified by surface mining activities; Moderate Concern: LCM = 0.2–0.8 or LCM > 0.8 AND landscape/soils modified by surface mining activities; Significant Concern: LCM < 0.2, landscape/soils greatly modified by surface mining activities

- Plant community composition condition: Information on condition of natural and successional forests, shrublands, grasslands, and wetland communities at FLNI is found in WPC (2005, Turcotte et al. (2012), Marconi and Knee (2013), and Yeany (2019) along with supporting fieldwork at FLNI conducted in 2018 by the WPC. These field inventories were used to asign reference condition and status values (current condition and trends) for FLNI. Yeany's (2019) assessment of grassland bird habitat and rapid field surveys by WPC (WPC 2005) detected considerable variation in habitat quality throughout FLNI. Observations from Marconi and Knee (2013) for invasive species presence in these habitats were consistent with the observations from Yeany (2019). Less is known about the condition of the natural forest communities. The condition metric for natural forest communities evaluates the degree of degradation to the native plant species, including decline in native species diversity and loss of key diagnostic species and can be measured by comparing plant community composition of the patch to the plant species list found in the Pennsylvania Plant Community Classification (Fike 1999, Zimerman et al 2012). This metric is a key component in NatureServe's vegetation metrics of their Ecological Integrity Assessment (Faber-Langendoen et al. 2012, Faber-Langendoen et al. 2016, Rocchio and Crawford 2009). The following describes the metrics used to evaluate condition of natural plant communities and successional cover types:

    - Natural communities and successional cover types – Good condition: Relative cover 100% native plant species made up of native plant species; composition reflects description of natural communities in PA Plant Community Classification; Moderate Concern: relative cover dominated by native plant species, composition reflects description of natural plant composition in PA Plant Community Classification; Significant Concern: Relative cover < 60% native plant species; composition does not reflect natural communities identified in PA Plant Community Classification (anthropogenic/ruderal community).

Condition and Trend

Condition of landscape context: Condition scores for context of all-natural community types and successional cover types are found in Table 4-20. Mean landscape condition scores were calculated for all-natural community and successional land cover patches at FLNI (Table 4-19, Figure 4-10). Mean landscape condition scores for natural forest community types ranged from 0.82 for Black locust forest to 0.96 for Black cherry – northern hardwood forests. Black locust forest is often found on disturbed lands and often indicates significant anthropogenic disturbance. Mean landscape

condition scores for Successional forests, woodlands, and shrublands fell between 0.84 and 0.92. Two community types with markedly lower mean landscape condition scores were Conifer plantation (0.70) and Cat-tail marsh (0.77); Cat-tail marshes are associated with constructed wetlands built to treat abandon mine discharge. Despite occurring primarily on reclaimed strip mine land, modified terrestrial herbaceous habitat (Grasslands) averaged 0.82, suggesting a relatively good landscape context.

Table 4-20. Condition of landscape context for natural and successional/modified community types at Flight 93 National Memorial with associated trend and confidence scores.

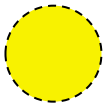
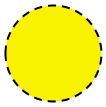
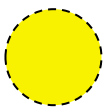
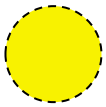
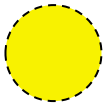
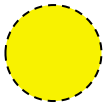
Indicator	Metric	Status and Trend	Rationale and Reference Conditions
Landscape Context of Forest Communities	Landscape condition score		• **Condition**: Mean landscape condition score of = 0.87 or greater for features of this type; good condition based on landscape context. • **Trend**: No trend information is available • **Confidence**: confidence is low; modeled data used to score condition; limited on-site data to verify ecological quality.
Landscape Context of successional Woodland Communities	Landscape condition score; impacts to landscape/soils from surface mining activities		• **Condition**: Mean landscape condition score of 0.85 for features of this type; moderate concern based on landscape context; patches occur on reclaimed strip mine land. • **Trend**: No trend information is available. • **Confidence**: confidence is low; modeled data used to score condition; limited on-site data to verify ecological quality.
Landscape Context of Grassland Communities (*Modified terrestrial herbaceous habitat*)	Landscape condition score; impacts to landscape/soils from surface mining activities		• **Condition** Mean landscape condition score of 0.82 for features of this type; moderate concern based on landscape context; patches occur on reclaimed strip mine land. • **Trend**: Trend improving; high potential habitat for grassland species of birds. • **Confidence**: confidence is high; modeled data used to score condition; however, on-site data was available to verify ecological quality.
Landscape Context of wetland plant communities (e.g. Cat-tail marsh)	Landscape condition score; impacts to landscape/soils from surface mining activities		• **Condition**: Mean landscape condition score of 0.77 for features of this type; moderate concern based on landscape context. Patches occur within constructed wetlands to treat Abandoned Mine Discharge (AMD). • **Trend**: No trend information is available. • **Confidence**: confidence is low; modeled data used to score condition; no on-site data to verify ecological quality.

Table 4-20 (continued). Condition of landscape context for natural and successional/modified community types at Flight 93 National Memorial with associated trend and confidence scores.

Indicator	Metric	Status and Trend	Rationale and Reference Conditions
Landscape Context of Conifer plantations	Landscape condition score (LCM); impacts to landscape/soils from surface mining activities		• **Condition**: Mean landscape condition score of 0.70 for features of this type; moderate concern based on landscape context; patches occur on reclaimed strip mine land. • **Trend**: No trend information is available. • **Confidence**: confidence is low; modeled data used to score condition; no on-site data to verify ecological quality
Landscape Context of Successional shrubland communities	Landscape condition score; impacts to landscape/soils from surface mining activities		• **Condition**: Mean landscape condition score of 0.92 for features of this type; moderate concern based on landscape context; patches occur on reclaimed strip mine land. • **Trend**: No trend information is available. • **Confidence**: confidence is low; modeled data used to score condition; no on-site data to verify ecological quality.
Landscape Context of Modified palustrine / floodplain herbaceous habitat	Landscape condition score; impacts to landscape/soils from surface mining activities		• **Condition**: Mean landscape condition score of 0.88 for features of this type; moderate concern based on landscape context; patches occur on reclaimed strip mine land. • **Trend**: No trend information is available. • **Confidence**: confidence is low; modeled data used to score condition; no on-site data to verify ecological quality.

Because the LCM (PNHP 2016) was constructed using remote sensing data from a single time point (NLCD 2011), and the dissonance between the LCM assessment and field visits, the metric used to evaluate all non-forest successional plant communities was modified to reflect their location on reclaimed mine lands. This resulted in designating all successional community types as moderate concern, despite possessing a mean landscape context score above 0.8 (Table 4-19). While anthropogenic grasslands provide habitat or potential habitat for grassland species of birds and other wildlife, they represent considerably modified habitats, and therefore did not receive a condition score of "good."

Condition of plant community composition: Condition scores for composition of all-natural community types and successional cover types are found in Table 4-21. Except for the *Modified terrestrial herbaceous habitat*, in which field data on plant and bird species composition is plentiful (Yeany 2019), field data indicating condition and trends in ecological quality of all other plant communities at FLNI is lacking overall. Condition of natural forest communities can be inferred from rapid field assessment conducted by WPC during the 2018 fieldwork for this NRCA and work done in 2005 as part of mapping activities (WPC 2005). Forest community patches at FLNI were easily assigned to natural forest plant communities described in the Pennsylvania Plant Community

Classification (Fike 1999, Zimmerman et al. 2012) and were composed primarily of native plant cover. There were, however, some invasive non-native plant species noted within natural forest communities. Limited information on condition of successional forests, woodlands, shrublands, and modified terrestrial herbaceous habitat (grasslands), and wetland communities at FLNI was reported in WPC (2005), Turcotte et al. (2012), Marconi and Knee (2013), and Yeany (2019). These field inventories were used to asign reference condition and status values (current condition and trens) for grassland successional community patches FLNI. Yeany's (2019) assessment of grassland bird habitat and rapid field surveys by WPC (WPC 2005) detected considerable variation in habitat quality throughout FLNI. Observations from Marconi and Knee (2013) for invasive species presence in these habitats were consistent with the observations from Yeany (2019).

Table 4-21. Condition scores for the native composition of natural and successional/modified community types at Flight 93 National Memorial with their associated trend and confidence.

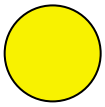
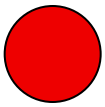
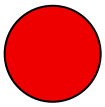
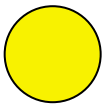
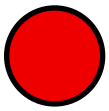
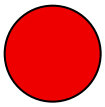
Indicator	Metric	Status and Trend	Rationale and Reference Conditions
Condition of Forest communities	Cover of native plant species; composition reflects description of natural communities in PA Plant Community Classification		• **Condition**: Moderate concern; recognizable forest communities; non-native plants present in all patches; hemlock wooly adelgid present in hemlock forest types • **Trend**: If treatment of hemlock wooly adelgid is not continued in the future, the condition of forest communities with hemlock will decline due to hemlock die-off. • **Confidence**: confidence is medium; limited on-site data to verify ecological quality.
Condition of Woodland communities (*Successional woodland*)	Cover of native plant species; composition reflects description of natural communities in PA Plant Community Classification		• **Condition**: Significant concern; woodland community patches not described in PA Plant Community Classification; early successional and non-native plants dominate all patches. • **Trend**: No trend information is available. • **Confidence**: confidence is medium; limited on-site data to verify ecological quality.
Condition of Shrubland communities (*Successional shrubland*)	Cover of native plant species; composition reflects description of natural communities in PA Plant Community Classification		• **Condition**: Significant concern; shrubland community patches not described in PA Plant Community Classification; early successional and non-native plants dominate all patches. • **Trend**: No trend information is available. • **Confidence**: confidence is medium; limited on-site data to verify ecological quality.

Table 4-21 (continued). Condition scores for the native composition of natural and successional/modified community types at Flight 93 National Memorial with their associated trend and confidence.

Indicator	Metric	Status and Trend	Rationale and Reference Conditions
Condition of Grassland communities (*Modified terrestrial herbaceous habitat*)	Cover of native plant species; composition reflects description of natural communities in PA Plant Community Classification		• **Condition**: Significant concern; grassland community patches not described in PA Plant Community Classification; early successional and non-native plants dominate all patches. • **Trend**: Trend improving; high potential habitat for grassland species of birds. • **Confidence**: confidence is high; on-site data to verify ecological quality from 2018 fieldwork and other sources which include Western Pennsylvania Conservancy (2005), Marconi and Knee (2013), and Yeany (2019).
Condition of wetland plant communities (e.g. cat-tail marsh)	Cover of native plant species; composition reflects description of natural communities in PA Plant Community Classification		• **Condition**: Moderate concern; wetland community patches described in PA Plant Community Classification; early successional and non-native plants common in all patches. • **Trend**: No trend information is available. • **Confidence**: confidence is medium; limited on-site data to verify ecological quality.
Condition of Conifer plantations	Cover of native plant species; composition reflects description of natural communities in PA Plant Community Classification		• **Condition**: Significant concern; conifer community patches not described in PA Plant Community Classification; planted and non-native plants dominate all patches. • **Trend**: No trend information is available. • **Confidence**: confidence is high; on-site data to verify ecological quality found in Western Pennsylvania Conservancy (2005), Marconi and Knee (2013), and Yeany (2019), and from fieldwork conducted in 2018.
Condition of modified palustrine/floodplain herbaceous communities	Cover of native plant species; composition reflects description of natural communities in PA Plant Community Classification		• **Condition**: Significant concern; wetland community patches not described in PA Plant Community Classification; early successional and non-native plants common in all patches. • **Trend**: No trend information is available. • **Confidence**: confidence is medium; limited on-site data to verify ecological quality.

Level of Confidence and Data Gaps

Landscape Context Condition

The confidence in the assessment was low for all Ecological Quality scores for natural and successional/cultural plant community patches because the assessment was based on remote sensing data. Quantitative sampling of vegetation and detailed systematic analysis of ecological condition and integrity (e.g. Ecological Integrity Analysis, Faber-Langendoen et al. 2016) are recommended.

Plant Community Composition Condition

Except for the *Modified terrestrial herbaceous habitat*, in which field data on plant and bird species composition is plentiful, field data indicating condition and trends in ecological quality of plant communities at FLNI is scarce. Rapid field-data were collected in 2005 (WPC 2005) and 2018 (Yeany 2019), as well as a small number of quantitative community classification plots established within grassland community patches. However, these data do not represent a comprehensive, systematic assessment of ecological quality over the entire FLNI landscape. Therefore, confidence in landscape condition scores of most natural communities and successional types as metrics of Ecosystem Quality are low. Confidence in the *Modified terrestrial herbaceous habitat* was reported as high because of Yeany's effort (2019). Scoring of ecological integrity requires significantly more field data from each community type patch at FLNI, as well as an in-depth assessment of disturbance. Furthermore, because each natural community and successional type at FLNI can be experiencing different stressors, each occurrence of each type should be examined in an analysis of ecological integrity

Source(s) of Expertise

- The PA LCM was generated by the PNHP (2016), which was based on the work of Comer and Hak (2012).
- Natural community mapping was provided by the WPC specifically for this NRCA, plus existing work from WPC (2005).
- Rapid field assessment and invasive plant inventory are reported in WPC (2005), Marconi and Knee (2013), and Yeany (2019).

Culturally Significant Features

Specific landscape units containing culturally significant features were mapped and evaluated with the same metrics applied to natural community and successional land cover patches at FLNI (see 4.5.1). These metrics may be an imperfect method for evaluating managed landscape features, but it is the best tool available to provide metrics for the NRCA. The culturally significant features include six areas: the Allee and Memorial Groves, Visitor Center Complex, Tower of Voices, Hemlock Grove, Impact Site (approximation), and the Memorial.

Landscape context condition scores calculated from the LCM (PNHP 2016) for the six landscape units possessing culturally significant features at FLNI indicate that all but one (Hemlock Grove) are of moderate concern. Except for the Hemlock Grove, all other features occur on reclaimed strip mine land and are routinely managed. The Hemlock Grove is the most "natural" of all culturally significant features and was given a landscape context condition score of good.

The pattern was similar for condition of plant community composition for the six culturally significant features. All but one of the features (Hemlock Grove) were of moderate concern. They are highly managed and do not reflect the composition of natural communities in Pennsylvania. An exception, the Hemlock Grove is in good condition and is a recognizable forest community type in Pennsylvania, however, the presence of HWA could degrade this feature in the near future.

Indicator Description

In addition to the natural and successional community types at FLNI, there are significant features that make up the cultural component of the Park. These features have been established or are maintained to honor the passengers and crew of Flight 93 and their families. The culturally significant features include the Allee and Memorial Groves, Visitor Center Complex, Tower of Voices, Hemlock Grove, Impact Site (approximation), and the Memorial Plaza.

Threats and stressors associated with the culturally significant features are identical to the threats and stressors identified for the natural and successional plant community types at FLNI. Invasive plants and insect pests are a significant threat to native species that are important to defining species composition and aesthetics of culturally significant communities. Except for the Memorial Grove, which is a patch of natural Hemlock forest community, the vegetation within all culturally significant areas can be described as "early successional," or "managed," and these habitat types may be easily impacted by invasive plant species. Woody invasive species may colonize managed and unmanaged meadows and shrublands, which impacts ecological integrity (e.g. ability to support obligate grassland birds, Yeany 2019; see Chapter 4.4.1), and aesthetics of culturally significant features. HWA is a major threat to the Hemlock Grove, a culturally significant feature. HWA has been documented in this feature, and this area has received significant management attention (Turcotte et al. 2012).

Data and Methods

As part of the FLNI NRCA, WPC mapped landscape features at FLNI (see also Chapter 4.5.1) using areal imagery in ArcGIS (Source: Esri DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community) including the following Culturally Significant Features at FLNI (Figures 2-12 and 12-3): Allee and Memorial Groves, Visitor Center Complex, Tower of Voices, Hemlock Grove, Impact Site (approximation), and the Wall of Names (including walkway to the Wall of Names).

Landscape condition scores calculated from the PNHP LCM (PNHP 2016) for the landscape units with culturally significant features at FLNI indicate that most areas are of moderate concern (Figure 4-10, Table 4-22) (see 4.5.1 for discussion on limitations of this assessment). Except for the Hemlock Grove, all other culturally significant features at FLNI are located on landscapes that have been modified by previous strip-mining activities and are now highly managed.

Table 4-22. Landscape condition model (LCM) results (PNHP 2016) summarized by culturally significant feature at Flight 93 National Memorial (FLNI).

Community Type	LCM Min	LCM Max	LCM Mean	Standard Deviation
The Allee and Memorial Groves	0.68	0.97	0.85	0.05
Visitor Center Complex	0.80	0.87	0.84	0.03
Tower of Voices	0.77	0.87	0.82	0.03
Hemlock Grove	0.76	1.00	0.89	0.09
Impact Site (Approximate)	0.84	0.87	0.85	0.01
Memorial Plaza	0.85	0.89	0.87	0.02

Reference Conditions/Values

All areas possessing culturally significant features were evaluated to determine Ecosystem Quality values for FLNI using the Pennsylvania LCM (PNHP 2016) for general landscape context, plus information from field activities presented in WPC (2005), Yeany (2019), and rapid field assessments performed in 2018 by WPC as part of vegetation mapping activities.

A field-based systematic evaluation of ecological integrity of vegetation communities (e.g. Perles et al. 2010, Comiskey and Wakamiya 2011) has not been conducted at FLNI. Therefore, the current conditions and trends relied on existing community classification information from a property evaluation prior to the establishment of the memorial by WPC (2005) and recent evaluation of the grassland bird habitat (Yeany 2019). Yeany's evaluation included sites within the Allee and Memorial Groves and Visitor Center Complex. Additional rapid field evaluations were conducted within the Hemlock Grove, Tower of Voices, and the Memorial Plaza. No on-the-ground assessments were conducted at The Impact Site. Rapid field assessments were conducted by WPC using traditional Natural Heritage methodology for evaluating plant community occurrences (NatureServe 2002), which uses landscape context and condition to rank plant community occurrences from A-D. Landscape context and condition are measures of ecological integrity of a landscape unit, which evaluates the "outer workings" (context) and "inner workings" (condition) of an ecosystem (Faber-Langendoen et al. 2016). A good landscape condition score suggests that the feature exists in a continuous/connected landscape that supports all requirements needed to sustain native ecosystems and ecological processes. Additional rapid evaluation techniques can be found in (Faber-Langendoen et al. 2012, 2016, Rocchio and Crawford 2009). Results of all evaluations are summarized in this section and include the following:

- Condition of landscape context: LCM scores were determined for each area supporting Culturally Significant Features; scores reflect presence and proximity to anthropogenic disturbance. The LCM for Pennsylvania (PNHP 2016) utilizes remotely sensed data and often scores reclaimed mined lands similarly to native grasslands. Therefore, scores may not completely reflect the ecological condition of natural communities and successional types at FLNI.

- Hemlock Grove – Good landscape condition: LCM > 0.8; Moderate Concern: LCM = 0.2–0.8; Significant Concern: LCM < 0.2

- Allee and Memorial Groves, Visitor Center Complex, Tower of Voices, Hemlock Grove, Impact Site (approximation), and the Memorial Plaza – Good landscape condition: LCM > 0.8, landscape/soils *not modified* by surface mining activities; Moderate Concern: LCM = 0.2–0.8 or LCM > 0.8 AND landscape/soils *modified* by surface mining activities; Significant Concern: LCM < 0.2, landscape/soils *greatly modified* by surface mining activities.

- Condition of plant community composition: Information on condition of the Allee and Memorial Groves, Visitor Center Complex, Tower of Voices, and the Memorial Plaza. forests, shrublands, grasslands, and wetland communities at FLNI is found in WPC (2007, 2018), Yeany (2019), and Marconi and Knee (2013). Field inventories were used to asign reference condition and status values (current condition and trens) for FLNI. Yeany's (2019) assessment of grassland bird habitat and rapid field surveys by WPC (WPC 2005) detected considerable variation in habitat quality throughout FLNI. Observations from Marconi and Knee (2013) for invasive species presence in these habitats were consistent with the observations from Yeany (2019). Hemlock Wooly Adelgid (HWA), an invasive insect, is a major threat to the Hemlock Grove, a culturally significant feature. HWA has been documented in this feature, and this area has received significant management attention (Turcotte et al. 2012).

  The condition metric for vegetation within Cultrually Significant Features evaluates the degree of degradation to the native plant species, including decline in native species diversity and loss of key diagnostic species and can be measured by comparing plant community composition of the patch to the plant species list found in the Pennsylvania Plant Community Classification (Fike 1999). This metric is a key component in NatureServe's vegetation metrics of their Ecological Integrity Assessment (Faber-Langendoen et al. 2012, Faber-Langendoen et al. 2016, Rocchio and Crawford 2009). The following further describes the metric used to evaluate condition of natural plant communities and successional cover types:

  - Culturally Significant Features – Good condition: Relative cover 100% native plant species made up of native plant species; composition reflects description of natural communities in PA Plant Community Classification; Moderate Concern: relative cover dominated by native plant species, composition reflects description of natural plant composition in PA Plant Community Classification; Significant Concern: Relative cover < 60% native plant species; composition does not reflect natural communities identified in PA Plant Community Classification (anthropogenic/ruderal community).

Condition and Trend

Condition of landscape context: Mean landscape condition scores were calculated for all areas containing Culturally Significant Features at FLNI (Table 4-22, Figure 2-10). Mean landscape

condition scores ranged from 0.89 for the Hemlock Grove to 0.82 for the Tower of Voices. Despite the high landscape context scores (all > 0.8), all areas containing Culturally Significant Features other than the Hemlock Grove occur on reclaimed strip mine land. Furthermore, only the Hemlock Grove represents a natural community type; all others are managed landscapes and situated on heavily impacted land. Therefore, only the Hemlock Grove was given a score of "good," despite the results of the LCM (Table 4-23).

Table 4-23. Condition of landscape context with associated trend and confidence scores for culturally significant communities at Flight 93 National Memorial.

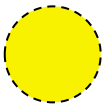
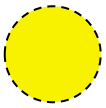
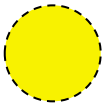
Indicator	Metric	Status and Trend	Rationale and Reference Conditions
Landscape Context of the Allee and Memorial Groves	Landscape condition score; impacts to landscape/soils from surface mining activities		• **Condition**: Mean landscape condition score of 0.85 for features of this type; Moderate concern based on landscape context. Site occurs on reclaimed strip mine land and is routinely managed. • **Trend**: no trend data available. • **Confidence**: confidence is low; modeled data used; no on-site data to verify quality.
Landscape Context of the Visitor Center Complex	Landscape condition score; impacts to landscape/soils from surface mining activities		• **Condition**: Mean landscape condition score of 0.84 for features of this type; Moderate concern based on landscape context. Site occurs on reclaimed strip mine land and is routinely managed. • **Trend**: no trend data available. • **Confidence**: confidence is low; modeled data used; no on-site data to verify quality.
Landscape Context of the Tower of Voices	Landscape condition score; impacts to landscape/soils from surface mining activities		• **Condition**: Mean landscape condition score of 0.82 for features of this type; Moderate concern based on landscape context. Site occurs on reclaimed strip mine land and is routinely managed. • **Trend**: no trend data available. • **Confidence**: confidence is low; modeled data used; no on-site data to verify quality.
Landscape Context of the Hemlock Grove	Landscape condition score (modeled)		• **Condition**: Mean landscape condition score of 0.89 for features of this type; Good condition based on landscape context, but HWA is present and could cause a decline in Hemlock trees. • **Trend**: no trend data available. • **Confidence**: confidence is low; modeled data used; no on-site data to verify quality.

Table 4-23 (continued). Condition of landscape context with associated trend and confidence scores for culturally significant communities at Flight 93 National Memorial.

Indicator	Metric	Status and Trend	Rationale and Reference Conditions
Landscape Context of the Site (Approximate location based on WPC data)	Landscape condition score; impacts to landscape/soils from surface mining activities		• **Condition**: Mean landscape condition score of 0.84 for features of this type; Moderate concern based on landscape context. Site occurs on reclaimed strip mine. • **Trend**: no trend data available. • **Confidence**: confidence is low; modeled data used; no on-site data to verify quality.
Landscape context of the Memorial Plaza	Landscape condition score; impacts to landscape/soils from surface mining activities		• **Condition**: Mean landscape condition score of 0.87 for features of this type; moderate concern based on landscape context. Site occurs on reclaimed strip mine land and is routinely managed. • **Trend**: no trend data available. • **Confidence**: confidence is low; modeled data used; no on-site data to verify quality.

Because the LCM (PNHP 2016) was constructed using remote sensing data from a single time point (NLCD 2011), and the dissonance between the LCM assessment and field visits, the metric used to evaluate all non-forest successional plant communities was modified to reflect their location on reclaimed mine lands. This resulted in designating all successional community types as moderate concern, despite possessing a mean landscape context score above 0.8.

Condition of plant community composition: Only the Hemlock Grove represents a natural community type - Hemlock (white pine) forest. All other areas supporting Culturally Significant are situated on formerly mined lands and are routinely managed. Condition scores for Culturally Significant Features are found in Table 4-24.

Table 4-24. Condition of plant community composition with associated trend, and confidence scores for culturally significant communities at Flight 93 National Memorial.

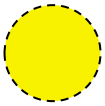
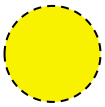
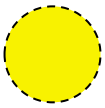
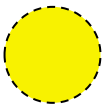
Indicator	Metric	Status and Trend	Rationale and Reference Conditions
Condition of the Allee and Memorial Groves	Cover of native plant species; composition reflects description of natural communities in PA Plant Community Classification; planting and routine vegetation management occurs regularly		• **Condition**: Moderate concern; managed landscape; invasive plant species present. • **Trend**: no trend data available. • **Confidence**: confidence is low; modeled data used; no on-site data to verify quality.

Table 4-24 (continued). Condition of plant community composition with associated trend, and confidence scores for culturally significant communities at Flight 93 National Memorial.

Indicator	Metric	Status and Trend	Rationale and Reference Conditions
Condition of the Visitor Center Complex	Cover of native plant species; composition reflects description of natural communities in PA Plant Community Classification; planting and routine vegetation management occurs regularly		• **Condition**: Moderate concern; managed landscape; invasive plant species present. • **Trend**: no trend data available. • **Confidence**: confidence is low; modeled data used; no on-site data to verify quality.
Condition of the Tower of Voices	Cover of native plant species; composition reflects description of natural communities in PA Plant Community Classification; planting and routine vegetation management occurs regularly		• **Condition**: Moderate concern; managed landscape; invasive plant species present. • **Trend**: no trend data available. • **Confidence**: confidence is low; modeled data used; no on-site data to verify quality.
Condition of the Hemlock Grove	Cover of native plant species; composition reflects description of natural communities in PA Plant Community Classification; hemlock wooly adelgid monitoring and treatment activities occurring		• **Condition**: Good condition; recognizable forest communities; non-native plants present in all patches; hemlock wooly adelgid present in hemlock forest types. • **Trend**: If treatment of hemlock wooly adelgid is not continued in the future, the condition of this plant community will decline due to hemlock die-off. • **Confidence**: confidence is low; limited on-site data to verify quality.
Condition of the Site (Approximate location based on WPC data)	Cover of native plant species; composition reflects description of natural communities in PA Plant Community Classification; planting and routine vegetation management occurs regularly		• **Condition**: Moderate concern; managed landscape; invasive plant species present. • **Trend**: no trend data available. • **Confidence**: confidence is low; modeled data used; no on-site data to verify quality.
Condition of the Memorial Plaza	Cover of native plant species; composition reflects description of natural communities in PA Plant Community Classification; planting and routine vegetation management occurs regularly		• **Condition**: Moderate concern; managed landscape; invasive plant species present. • **Trend**: no trend data available. • **Confidence**: confidence is low; modeled data used; no on-site data to verify quality.

Level of Confidence and Data Gaps

Landscape condition context

The confidence in the assessment was low as all Ecological Quality scores for natural and successional/cultural plant community patches were based on remote sensing data. Quantitative sampling of vegetation and detailed systematic analysis of ecological condition and integrity (e.g. Ecological Integrity Analysis, Faber-Langendoen et al. 2016) are recommended.

Condition of plant community composition

Except for the Memorial Grove, in which field data on the condition of the hemlocks and presence of HWA exists, field data indicating condition and trends in ecological quality of Culturally Significant Features at FLNI is scarce. Rapid field-data were collected in 2005 (WPC 2005) and 2018 (Yeany 2019), as well as a small number of quantitative community classification plots from 2018 fieldwork established within some areas. However, these data do not represent a comprehensive, systematic assessment of ecological quality over the entire FLNI landscape. Therefore, confidence in landscape condition scores of most natural communities and successional types as metrics of Ecosystem Quality are low. Scoring of ecological integrity requires significantly more field data from each Culturally Significant Feature at FLNI, as well as an in-depth assessment of disturbance. Furthermore, because each natural community and successional type at FLNI can be experiencing different stressors, each occurrence of each type should be examined in an analysis of ecological integrity.

Source(s) of Expertise

- The LCM was generated by the PNHP (2016), which was based on the work of Comer and Hak (2012).
- Natural community mapping and spatial data for culturally significant freatures were provided by the WPC.
- Rapid field assessment and invasive plant inventory are reported in WPC (2005), Marconi and Knee (2013), and Yeany (2019).

Discussion

Generally speaking, the NRCA for Flight 93 National Memorial has revealed substantial data gaps for many resource indicators. FLNI should explore partnership opportunities with local universities, conservation organizations, and/or state and federal entities to perform on-site monitoring ecological response to threats and stressors. FLNI should also coordinate with the Eastern Rivers and Mountains Monitoring Network (ERMN) for any on-site monitoring or partner-driven research: this will ensure compliance with data collection standards for NPS-I&M but allow FLNI and ERMN to utilize partnership opportunities to boost capacity.

FLNI and other southwestern Pennsylvania NPS sites (ALPO, JOFL, FRHI, and FONE) support diverse natural communities, successional features, and culturally significant features. These NPS sites were established to highlight the historic value of the southwestern Pennsylvania landscape, but also contain valuable biological and ecological features that should be considered in the context of cultural resource management. Recognizing the ecological strengths and weaknesses of each NPS site in southwestern Pennsylvania, and managing for ecosystem resilience, could be an efficient and sustainable natural resource management strategy for NPS. FLNI contains many early successional features that support state-listed bird species, and a robust obligate grassland bird community (Yeany 2019). These early successional grasslands, meadows, and shrublands have the potential to support diverse flora and pollinators and could provide other habitat for other wildlife. The soils and topography at FLNI are highly disturbed and managing towards early successional biodiversity is probably more efficient and sustainable that reforestation of the site.

Air Quality

Metrics for wet deposition of nitrogen and sulfur, and visibility all warrant significant concern at FLNI, and wet deposition of mercury and ground-level ozone metrics warrant moderate concern. Estimates for air quality indicators were consistent with air quality data from other southwestern NPS sites. This suggests that air quality stressors, such as fossil fuel combustion from electric power generation, automobiles, and/or local industry or agriculture, could be degrading air quality in southwestern Pennsylvania. Most data for air quality indicators at FLNI were derived from spatial interpolation of data from remote stations outside of FLNI. On-site monitoring stations should be considered to more closely monitor ground-level ozone and wet deposition of sulfur, nitrogen, and mercury. Visibility should also be monitored on-site. This would enhance confidence scores for air quality indicators and would allow FLNI to score trends for each air quality indicator.

Suggested actions to support Air Quality at FLNI:

- Explore opportunities for air quality monitoring at FLNI: on-site data will provide a more accurate condition score for air quality metrics and monitoring over time will allow FLNI to adjust biological or ecological monitoring targets as air quality conditions improve or degrade.

- Monitor the potential impact of wet deposition or ground-level ozone on species or ecological communities.

Night Sky and Acoustic Quality

Night sky was found to be in good quality for FLNI. Although FLNI is considered to be a Level 2 park (lacking natural features that suggest a higher degree of sensitivity to light pollution), night skies could provide a regionally valuable evening experience for visitors at FLNI. The importance of night sky conditions for biological targets has not been studied in southwestern Pennsylvania. Potential research targets could include pollinators that are active at night, breeding activity of amphibian species that could be impacted by light pollution, or breeding/migratory birds that utilize FLNI.

Suggested actions to support Night Sky and Acoustic Quality at FLNI:

- Explore programming opportunities that highlight the regional value of night skies at FLNI.
- Examine the composition and diversity of biological targets that are sensitive to excess ambient light or sound (baseline data).
- Design monitoring strategies to understand the impact (if any) of excess ambient light or noise on sensitive biological targets.

Stream Water Quality

The Lamberts Run watershed has been highly modified due to surface mining which has resulted in AMD contamination to water sources within FLNI and the surrounding area. However, the installation of passive treatment systems along Lamberts Run has resulted in improved water quality. Within the FLNI boundaries, only one monitoring station is located on Lamberts Run. Data from this monitoring location have not been collected since 2009, and other parameters should be measured at monitoring stations along Lamberts Run (temperature, specific conductance, and aquatic macroinvertebrates). To date, no stream water quality data have been collected from Grove Run. Enhancement of water quality monitoring at Lamberts Run will provide a current, comprehensive dataset to assess stream recovery, and initiation of water quality monitoring at Grove Run will provide baseline data to monitor stream water quality; both of these steps are necessary to develop data-drive management goals for aquatic resources at FLNI.

The lack of aquatic macroinvertebrate data was identified as a data gap for FLNI. No macroinvertebrate data currently exists for Lamberts Run and Grove Run yet they are an important component of stream ecosystems and provide useful insight into water quality. Numerous protocols, data bases, and interpretative tools already exist within the NPS and other agencies to potentially assist the park should they attempt to address filling these data gaps in the future.

Suggested actions to support Stream Water Quality at FLNI:

- Enhance stream water quality monitoring along Lamberts Run at FLNI, preferably downstream of AMD treatment infrastructure as the stream approaches a more natural physical setting.
- Initiate stream water quality monitoring along Grove Run at FLNI.

- Incorporate aquatic macroinvertebrate sampling into water quality monitoring at Lamberts Run and Grove Run.

Biological Quality

There is a significant lack of data for indicators of biological quality of FLNI, and baseline data collection for flora and fauna of FLNI should be a high priority. Once collected, baseline inventory data for biological resources can be used as an assessment tool to allow FLNI to systematically identify management and/or monitoring targets for biological resources. Through this assessment, FLNI should develop a list of biological resources that are valuable to the park, along with justification for why these resources are considered valuable. From there, FLNI can then develop potential management strategies for biological resources that are compatible with cultural resource management goals

Any management should be accompanied with a monitoring strategy. Monitoring strategies should be structured to not only provide information about population level changes but also include metrics to help interpret these changes. For some of the biological resources, like birds and invertebrates, monitoring metrics should include those related to climate change since it is likely to have an impact.

Scorable data for biological resources was limited to birds and bees. Early successional habitat and obligate grassland bird abundance data from Yeany's (2019) study of grasslands at FLNI suggests these resources are in good condition at FLNI. However, Yeany's (2019) data also indicated that habitat quality varies substantially throughout FLNI. This could have long-term consequences for obligate grassland bird species at FLNI, especially in habitats where trees are being actively planted to enhance forest regeneration. To determine appropriate management action, continuous, focused monitoring of grassland bird communities in grasslands, herbaceous meadows, and shrub-dominated/mid-successional communities may be necessary throughout the park.

Certain species can be valued natural resources but may also be stressors for other natural or cultural resources at FLNI. These species include white-tailed deer and Canada geese. White-tailed deer can have a significant impact on forest resources and could alter the trajectory of forest succession at FLNI. FLNI staff has reported that Canada geese can impact the visitor experience. Similar to other biological resources, FLNI will need to assess the value of white-tailed deer and Canada geese relative to their potential impact to cultural and natural resources and manage these species accordingly.

Suggested actions to support Biological Quality at FLNI:

- Perform formal inventories of plants, mammals, reptiles, amphibians, fish, forest interior and forest generalist birds, and terrestrial invertebrates at FLNI.

- Perform a values assessment for biological resources at FLNI; develop management and monitoring protocols accordingly. If appropriate, monitoring should also include metrics related to climate change.

- If obligate grassland birds are considered high value to FLNI, design long-term monitoring strategies for obligate grassland bird communities or species and use baseline data from Yeany (2019) and monitoring to inform management strategies for early successional habitats.

- Collect baseline data for stressor species, such as white-tailed deer or Canada geese, that could be impacting natural or cultural resource condition at FLNI.

Ecological Quality

Plant communities are ecologically connected to the other resources considered in the FLNI NRCA, therefore it was necessary to assess the condition of both the more "naturally" occurring plant communities along with the cultural features. Given the land-use history (mining, logging, and farming) of FLNI and the surrounding area, most of the landscape units have been modified and thus deviate in composition from the reference natural plant communities of Pennsylvania. Since a field-based systematic evaluation of ecological integrity of vegetation communities (e.g. Perles et al. 2010, Comiskey and Wakamiya 2011) was lacking for FLNI, the current conditions and trends of plant communities and cultural features relied on existing community classification information from a property evaluation by the WPC (2005) prior to the establishment of FLNI, the most current aerial imagery, and recent evaluation of the grassland bird habitat (Yeany 2019). A PNHP developed LCM (2016) was then applied using methods developed by NatureServe (Comer and Hak 2014) to obtain landscape condition scores and scores for the condition of plant community composition for all natural and cultural features. The methods used for assessment may have been less than ideal for the cultural features since they are highly managed and do not reflect the composition of natural communities in Pennsylvania, but it was the best method available for assessment.

Condition scores for natural communities, successional features, and culturally significant features suggest that the majority of mapped features at FLNI are in moderate to poor condition. This is not surprising given the land-use history of the area and that 13 of the 22 plant community types identified are successional/modified or non-natural. However, landscape condition scores are not a surrogate for site-specific habitat conditions. Yeany (2019) and WPC have reported variability in habitat quality throughout FLNI and that some of the successional types are good habitat for grassland birds and pollinators. A number of stressors, including invasive species and compacted soils, have been documented but not studied comprehensively. Because landscape condition scores are based on remote sensing data, and because of the discord between landscape condition scores and observed variability in habitat quality, confidence in landscape condition scores as metrics of Ecosystem Quality are low. Landscape condition scores can be informative about restoration potential but should be complimented with a compressive analysis of ecological integrity. At minimum, quantitative data should be collected from each natural community, successional type, and culturally significant feature at FLNI. This will enhance the classification of these features, but will also provide valuable data on site-specific stressors, such as invasive species.

Suggested actions to support Ecosystem Quality at FLNI:

- Use accepted NPS methodology from sources like ERMN to conduct baseline resource inventories and establish long-term monitoring of appropriate targets.
- Use the results of baseline resource inventories to further refine the FLNI resource map (Figure 2-10).

Based on the condition assessment, The Hemlock Grove is in good condition, but specific monitoring should be established to examine the impact of HWA and regeneration on this cultural feature.

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Appendix A. Bird checklist for Flight 93 National Memorial

Table A-1. Bird species checklist for Flight 93 National Memorial; created by Powdermill Nature Reserve (Pennsylvania ebird 2017).

Common Name	Scientific Name	Status
American Crow	*Corvus brachyrhynchos*	Permanent Resident
American Goldfinch	*Spinus tristis*	Year-round Resident and Migrant
American Kestrel	*Falco sparverius*	Year-round Resident and Migrant
American Robin	*Turdus migratorius*	Year-round Resident and Migrant
American Tree Sparrow	*Spizella arborea*	Migrant and Winter Resident
Baltimore Oriole	*Icterus galbula*	Migrant and Breeder
Bank Swallow	*Riparia riparia*	Migrant and Breeder
Barn Swallow	*Hirundo rustica*	Migrant and Breeder
Black-billed Cuckoo	*Coccyzus erythropthalmus*	Migrant and Breeder
Black-capped Chickadee	*Poecile atricapillus*	Year-round Resident and Migrant
Black-throated Green Warbler	*Setophaga virens*	Migrant and Breeder
Black Vulture	*Coragyps atratus*	Year-round Resident and Migrant
Blue-winged Teal	*Anas discors*	Migrant and Breeder
Blue Jay	*Cyanocitta cristata*	Year-round Resident and Migrant
Bobolink	*Dolichonyx oryzivorus*	Migrant and Breeder
Broad-winged Hawk	*Buteo platypterus*	Migrant and Breeder
Brown-headed Cowbird	*Molothrus ater*	Year-round Resident and Migrant
Brown Thrasher	*Toxostoma rufum*	Migrant and Breeder
Canada Goose	*Branta canadensis*	Year-round Resident and Migrant
Carolina Wren	*Thryothorus ludovicianus*	Permanent Resident
Cedar Waxwing	*Bombycilla cedrorum*	Permanent Resident
Chestnut-sided Warbler	*Setophaga pensylvanica*	Migrant and Breeder
Chimney Swift	*Chaetura pelagica*	Migrant and Breeder
Chipping Sparrow	*Spizella passerina*	Migrant and Breeder
Cliff Swallow	*Petrochelidon pyrrhonota*	Migrant and Breeder
Common Grackle	*Quiscalus quiscula*	Year-round Resident and Migrant
Common Raven	*Corvus corax*	Permanent Resident
Common Yellowthroat	*Geothlypis trichas*	Migrant and Breeder
Cooper's Hawk	*Accipiter cooperii*	Year-round Resident and Migrant
Dark-eyed Junco	*Junco hyemalis*	Year-round Resident and Migrant
Downy Woodpecker	*Picoides pubescens*	Permanent Resident
Eastern Bluebird	*Sialia sialis*	Year-round Resident and Migrant
Eastern Kingbird	*Tyrannus tyrannus*	Migrant and Breeder
Eastern Meadowlark	*Sturnella magna*	Year-round Resident and Migrant

Common Name	Scientific Name	Status
Eastern Phoebe	*Sayornis phoebe*	Migrant and Breeder
Eastern Towhee	*Pipilo erythrophthalmus*	Migrant and Breeder
Eastern Wood-Pewee	*Contopus virens*	Migrant and Breeder
European Starling	*Sturnus vulgaris*	Permanent Resident
Field Sparrow	*Spizella pusilla*	Migrant and Breeder
Grasshopper Sparrow	*Ammodramus savannarum*	Migrant and Breeder
Gray Catbird	*Dumetella carolinensis*	Migrant and Breeder
Great Blue Heron	*Ardea herodias*	Year-round Resident and Migrant
Great Crested Flycatcher	*Myiarchus crinitus*	Migrant and Breeder
Green Heron	*Butorides virescens*	Migrant and Breeder
Henslow's Sparrow	*Ammodramus henslowii*	Migrant and Breeder
Hooded Warbler	*Setophaga citrina*	Migrant and Breeder
Horned Lark	*Eremophila alpestris*	Year-round Resident and Migrant
House Sparrow	*Passer domesticus*	Permanent Resident
House Wren	*Troglodytes aedon*	Migrant and Breeder
Indigo Bunting	*Passerina cyanea*	Migrant and Breeder
Killdeer	*Charadrius vociferus*	Year-round Resident and Migrant
Least Flycatcher	*Empidonax minimus*	Migrant and Breeder
Least Sandpiper	*Calidris minutilla*	Migrant
Lesser Yellowlegs	*Tringa flavipes*	Migrant
Mallard	*Anas platyrhynchos*	Year-round Resident and Migrant
Mourning Dove	*Zenaida macroura*	Permanent Resident
Northern Cardinal	*Cardinalis cardinalis*	Permanent Resident
Northern Flicker	*Colaptes auratus*	Year-round Resident and Migrant
Northern Harrier	*Circus cyaneus*	Year-round Resident and Migrant
Northern Mockingbird	*Mimus polyglottos*	Permanent Resident
Northern Rough-winged Swallow	*Stelgidopteryx serripennis*	Migrant and Breeder
Northern Shrike	*Lanius excubitor*	Migrant and Winter Resident
Osprey	*Pandion haliaetus*	Migrant and Breeder
Ovenbird	*Seiurus aurocapilla*	Migrant and Breeder
Palm Warbler	*Setophaga palmarum*	Migrant
Pileated Woodpecker	*Dryocopus pileatus*	Permanent Resident
Prairie Warbler	*Setophaga discolor*	Migrant and Breeder
Purple Finch	*Haemorhous purpureus*	Year-round Resident and Migrant
Red-bellied Woodpecker	*Melanerpes carolinus*	Permanent Resident
Red-eyed Vireo	*Vireo olivaceus*	Migrant and Breeder
Red-headed Woodpecker	*Melanerpes erythrocephalus*	Year-round Resident and Migrant
Red-shouldered Hawk	*Buteo lineatus*	Year-round Resident and Migrant

Common Name	Scientific Name	Status
Red-tailed Hawk	*Buteo jamaicensis*	Year-round Resident and Migrant
Red-winged Blackbird	*Agelaius phoeniceus*	Migrant and Breeder
Ring-necked Duck	*Aythya collaris*	Migrant and Winter Resident
Ring-necked Pheasant	*Phasianus colchicus*	Permanent Resident
Rock Pigeon	*Columba livia*	Permanent Resident
Rose-breasted Grosbeak	*Pheucticus ludovicianus*	Migrant and Breeder
Ruddy Duck	*Oxyura jamaicensis*	Migrant and Breeder
Savannah Sparrow	*Passerculus sandwichensis*	Year-round Resident and Migrant
Scarlet Tanager	*Piranga olivacea*	Migrant and Breeder
Semipalmated Plover	*Charadrius semipalmatus*	Migrant
Snow Bunting	*Plectrophenax nivalis*	Migrant and Winter Resident
Solitary Sandpiper	*Tringa solitaria*	Migrant
Song Sparrow	*Melospiza melodia*	Year-round Resident and Migrant
Spotted Sandpiper	*Actitis macularius*	Migrant and Breeder
Swamp Sparrow	*Melospiza georgiana*	Year-round Resident and Migrant
Tree Swallow	*Tachycineta bicolor*	Migrant and Breeder
Tufted Titmouse	*Baeolophus bicolor*	Permanent Resident
Turkey Vulture	*Cathartes aura*	Year-round Resident and Migrant
Upland Sandpiper	*Bartramia longicauda*	Migrant and Breeder
Vesper Sparrow	*Pooecetes gramineus*	Migrant and Breeder
Warbling Vireo	*Vireo gilvus*	Migrant and Breeder
White-breasted Nuthatch	*Sitta carolinensis*	Permanent Resident
White-eyed Vireo	*Vireo griseus*	Migrant and Breeder
White-throated Sparrow	*Zonotrichia albicollis*	Year-round Resident and Migrant
Wild Turkey	*Meleagris gallopavo*	Permanent Resident
Willow Flycatcher	*Empidonax traillii*	Migrant and Breeder
Wood Duck	*Aix sponsa*	Year-round Resident and Migrant
Yellow-billed Cuckoo	*Coccyzus americanus*	Migrant and Breeder
Yellow-rumped Warbler	*Setophaga coronata*	Year-round Resident and Migrant
Yellow Warbler	*Setophaga petechia*	Migrant and Breeder

Appendix B. List of bee species detected Flight 93 National Memorial

Bee species collected at Flight 93 National Memorial (Kautz et al. 2018):

- *Agapostemon virescens*
- *Andrena cressoni*
- *Andrena fenningeri*
- *Andrena* sp.
- *Anthidium maniculatum*
- *Anthophora terminalis*
- *Apis mellifera*
- *Augochlora pura*
- *Augochlorella aurata*
- *Augochloroposis metallica*
- *Bombus bimaculatus*
- *Bombus fervidus*
- *Bombus griseocollis*
- *Calliopsis andreniformis*
- *Ceratina calcarata*
- *Ceratina dupla*
- *Ceratina mikmaqi*
- *Ceratina strenua*
- *Coelioxys rufitarsis*
- *Colletes* sp.
- *Colletes thoracicus*
- *Eucera* sp.

- *Halictus confusus*
- *Halictus ligatus*
- *Halictus rubicundus*
- *Hoplitis spoliata*
- *Hylaeus annulatus*
- *Hylaeus mesillae*
- *Lasioglossum (dialictus)* sp.
- *Lasioglossum (Evylaeus)* sp.
- *Lasioglossum (s.str.)* sp.
- *Megachile addenda*
- *Megachile campanulae*
- *Megachile frigida*
- *Megachile gemula*
- *Megachile inermis*
- *Megachile latimanus*
- *Megachile mucida*
- *Megachile pugnata*
- *Megachile sculpturalis*
- *Melissodes* sp.
- *Melitta americana*
- *Nomada* spp.
- *Osmia atriventris*
- *Osmia cornifrons*
- *Osmia* sp.
- *Osmia texana*

- *Peponapis pruinosa*
- *Ptilothrix bombiformis*
- *Triepeolus* sp.
- *Xylocopa virginica*

Appendix C. List of potential mammal species at Flight 93 National Memorial

In their summary of resources present, or that could be present at Flight 93 National Memorial (FLNI), the Western Pennsylvania Conservancy (WPC) provided a list of mammal species potentially found at FLNI, along with estimated probability of occurrence (WPC 2005; Table C-1).

Table C-1. Proposed list of mammal species that may occur at Flight 93 National Memorial (WPC 2005).

Common Name	Scientific Name	Habitat	Estimated Probability of Extant Population
Masked Shrew	*Sorex cinereus*	Moist forests and thickets	High
Southern Water Shrew	*Sorex palustris punctulatus*	Rocky streams in forested mountainous areas	Low
Water Shrew	*Sorex palustris albibarbis*	Rocky streams in forested areas; swamps, bogs	Subspecies not in area
Smoky Shrew	*Sorex fumeus*	Cool forests and swamps; with conifers	High
Long-tailed or Rock Shrew	*Sorex dispar*	Cool, moist very rock forests	Very low
Pygmy Shrew	*Sorex hoyi thompsoni*	Wide variety of habitats; mostly forests or wetlands	High
Maryland Shrew	*Sorex cinereus fontinalis*	Moist forests, thickets and openings	Very low
Northern Short-tailed Shrew	*Blarina brevicauda*	Wide variety of moist habitats; generalist	High
Least Shrew	*Cryptotis parva*	Meadows, old fields and grasslands	Very low
Hairy-tailed Mole	*Parascalops breweri*	Wide variety of moist habitats	Moderate
Eastern Mole	*Scalopus aquaticus*	Wide variety of habitats where soil is well-drained	Moderate
Star-nosed Mole	*Condylura cristata*	Bottomlands, riparian zones, wetlands; wet soils	Moderate
Little Brown Myotis	*Myotis lucifugus*	Wide variety of habitats, including water feature	High
Indiana or Social Myotis	*Myotis sodalis*	Forested regions; varies; including water feature	Low
Eastern Small-footed Myotis	*Myotis leibii*	Undetermined; varies; including water feature	Low - Moderate
Northern Myotis	*Myotis septentrionalis*	Varies; forested areas with cavities	Moderate
Silver-haired Bat	*Lasionycteris noctivagans*	Mixed and coniferous forests with water feature	Low
Eastern Pipistrelle	*Pipistrellus subflavus*	Varies; mixed habitats (forests, open) with water	High

Common Name	Scientific Name	Habitat	Estimated Probability of Extant Population
Big Brown Bat	*Eptesicus fuscus*	Wide variety of habitats, including water feature	High
Eastern Red Bat	*Lasiurus borealis*	Mixed habitats; forests and edges	Moderate
Hoary Bat	*Lasiurus cinereus*	Mixed habitats; coniferous/deciduous forests, edges	Low - Moderate
Evening Bat	*Nycticeius humeralis*	Variety of mixed habitats	Low
Eastern Cottontail	*Sylvilagus floridanus*	Variety of open habitats and forest openings	Documented
Appalachian Cottontail	*Sylvilagus obscurus*	Forests and dense thickets	Low - Moderate
Snowshoe Hare	*Lepus americanus*	High elevation forests with significant shrub layer	Low - Moderate
Eastern Chipmunk	*Tamias striatus*	Forests and thickets	Documented
Woodchuck	*Marmota monax*	Variety of open habitats and edges	High
Eastern Gray Squirrel	*Sciurus carolinensis*	Deciduous and mixed deciduous/coniferous forests	High
Eastern Fox Squirrel	*Sciurus niger*	Deciduous forests, open forests and edges	Moderate - High
Delmarva Fox Squirrel	*Sciurus niger cinereus*	Low elevation deciduous forests	Site not within range
Red Squirrel	*Tamiasciurus hudsonicus*	Coniferous and mixed coniferous/deciduous forests	High
Southern Flying Squirrel	*Glaucomys volans*	Deciduous forest	High
Northern Flying Squirrel	*Glaucomys sabrinus*	High elevation mixed deciduous/coniferous forests	Low
American Beaver	*Castor canadensis*	Streams, open or shrub wetlands; ponds and lakes	Low - Moderate
Deer Mouse	*Peromyscus maniculatus*	Wide variety of habitats	High
White-footed Mouse	*Peromyscus leucopus*	Wide variety of habitats	High
Allegheny Woodrat	*Neotoma magister*	Forested areas with rocky surfaces or outcrops	Low
Southern Red-backed Vole	*Clethrionomys gapperi*	Forests with fern and moss groundcover	High
Meadow Vole	*Microtus pennsylvanicus*	Meadows and other openings	High
Rock Vole	*Microtus chrotorrhinus*	High elevation mixed rocky forests and openings	Low
Woodland Vole	*Microtus pinetorum*	Wide variety of habitats from forests to fields	Moderate
Muskrat	*Ondatra zibethicus*	Streams and open wetlands, ponds and lakes	Moderate - High

Common Name	Scientific Name	Habitat	Estimated Probability of Extant Population
Southern Bog Lemming	*Synaptomys cooperi*	Variety of habitats; meadows, thickets, openings	Low - Moderate
Norway Rat	*Rattus norvegicus*	Urban, suburban and agricultural settings	Moderate - High
House Mouse	*Mus musculus*	Urban, suburban and agricultural settings	High
Meadow Jumping Mouse	*Zapus hudsonius*	Moist open habitats, thickets and edges	Moderate
Woodland Jumping Mouse	*Napaeozapus insignis*	Forests, thickets, rocky riparian areas	Moderate - High
Common Porcupine	*Erethizon dorsatum*	Mixed coniferous/deciduous and	High
Coyote	*Canus latrans*	Wide variety including human influenced habitats	High
Red Fox	*Vulpes vulpes*	Wide variety including human influenced habitats	Documented
Common Gray Fox	*Urocyon cinereoargenteus*	Forests, edges and openings	Moderate - High
Black Bear	*Ursus americanus*	Forests, thickets, wetlands	Moderate
Common Raccoon	*Procyon lotor*	Wide variety of habitats	High
Fisher	*Martes pennanti*	Remote forested landscapes	Low
Ermine	*Mustela erminea*	Variety of forests, thickets, hedgerows near water	Moderate-Low
Least Weasel	*Mustela nivalis*	Forests, thickets, meadows	Moderate
Long-tailed Weasel	*Mustela frenata*	Variety of habitats; forests, thickets, open areas	High
Mink	*Mustela vison*	Forests and other habitats near water	Moderate
Striped Skunk	*Mephitis mephitis*	Wide variety of habitats	High
Northern River Otter	*Lontra canadensis*	Medium to large streams, large wetlands and lakes	Low
Bobcat	*Felis rufus*	Remote forests with thickets and rocky areas	Documented
White-tailed Deer	*Odocoileus virginianus*	Wide variety of habitats	Documented

Appendix D. List of potential reptile species at Flight 93 National Memorial

In their summary of resources present, or that could be present at Flight 93 National Memorial (FLNI), the Western Pennsylvania Conservancy (WPC) provided a list of reptile species potentially found at FLNI, along with estimated probability of occurrence (WPC 2005; Table D-1).

Table D-1. Proposed list of reptile species that may occur at Flight 93 National Memorial (WPC 2005).

Common Name	Scientific Name	Habitat	Estimated Probability of Extant Population
Snapping Turtle	*Chelydra serpentina*	Streams, wetlands and bodies of water	Moderate
Northern Painted Turtle	*Chrysemys picta*	Streams, lakes and other water bodies	Low - Moderate
Spotted Turtle	*Clemmys guttata*	Marshes, wet meadows, borders of lakes	Low
Wood Turtle	*Clemmys insculpta*	Forested areas near streams	Low - Moderate
Bog Turtle	*Clemmys muhlenbergii*	Wet meadows, boggy marshes	Site not within range
Blanding's Turtle	*Emydoidea blandingii*	Bodies of water; lakes, marshes with open water	Site not within range
Map Turtle	*Graptemys geographica*	Large bodies of water; streams and lakes	Site not within range
Redbelly Turtle	*Pseudemys rubriventris*	Rivers, large creeks, ponds, lakes	Site not within range
Eastern Box Turtle	*Terrapene carolina*	Variety of forests, thickets, meadows, marshy areas	Moderate
Eastern Mud Turtle	*Kinosternon subrubrum*	Slow moving creeks, open wetlands	Site not within range
Stinkpot	*Sternotherus odoratus*	Streams, various wetlands and ponds	Site not within range
Spiny Softshell	*Apalone spinifera*	Rivers and large creeks	Site not within range
Eastern Fence Lizard	*Sceloporus undulatus*	Dry, warm forest openings; rocky slopes	Low
Coal Skink	*Eumeces anthracinus*	Openings in forest; woodlands; areas with cover	Low - Moderate
Five-lined Skink	*Eumeces fasciatus*	Openings in forest; open rocky areas	Low - Moderate
Kirtland's Snake	*Clonophis kirtlandii*	Wet meadows and bottomlands; marshy areas	Site not within range

Common Name	Scientific Name	Habitat	Estimated Probability of Extant Population
Black Racer	*Coluber constrictor*	Forest openings, edges, thickets	High
Ringneck Snake	*Diadophis punctatus*	Variety of upland habitats	High
Rat Snake	*Elaphe obsoleta*	Forests and forest edges	High
Eastern Hognose Snake	*Heterodon platirhinos*	Open forests, thickets; areas with loose soil	Low
Milk Snake	*Lampropeltis triangulum*	Variety of habitats; usually openings or edges	Moderate - High
Northern Water Snake	*Nerodia sipedon*	Water dominated areas; streams, wetlands, ponds	Moderate - High
Queen Snake	*Regina septemvittata*	Mostly streams; occasionally wetlands or ponds	Low - Moderate
Brown Snake	*Storeria dekayi*	Wide variety; forest to open areas	High
Redbelly Snake	*Storeria occipitomaculata*	Wide variety; forest to open areas	Moderate - High
Shorthead Garter Snake	*Thamnophis brachystoma*	Wide variety; especially open areas	Site not within range
Eastern Ribbon Snake	*Thamnophis sauritus*	Wide variety, but always near water	Low
Eastern Garter Snake	*Thamnophis sirtalis*	Wide variety; especially open areas	High
Mountain Earth Snake	*Virginia valeriae pulchra*	Upland deciduous or mixed forests with rocks, etc.	Low - Moderate
Smooth Green Snake	*Liochlorophis vernalis*	Upland open areas and thickets; stream banks	Moderate
Copperhead	*Agkistrodon contortrix*	Open rocky; edges or rocky forest openings	Low
Timber Rattlesnake	*Crotalus horridus*	Forests with rocky open areas	Low
Eastern Massasauga	*Sistrurus catenatus catenatus*	Open bottomlands, marshes, wet meadows	Site not within range

Appendix E. Natural community maps produced by the Western Pennsylvania Conservancy for Flight 93 National Memorial

This map of Flight 93 National Memorial was originally created for the Western Pennsylvania Conservancy (2005) rapid assessment and inventory submitted to Environmental Management Collaboration. Map symbology and text could not be adjusted because the original spatial data is no longer available (Figure E-1).

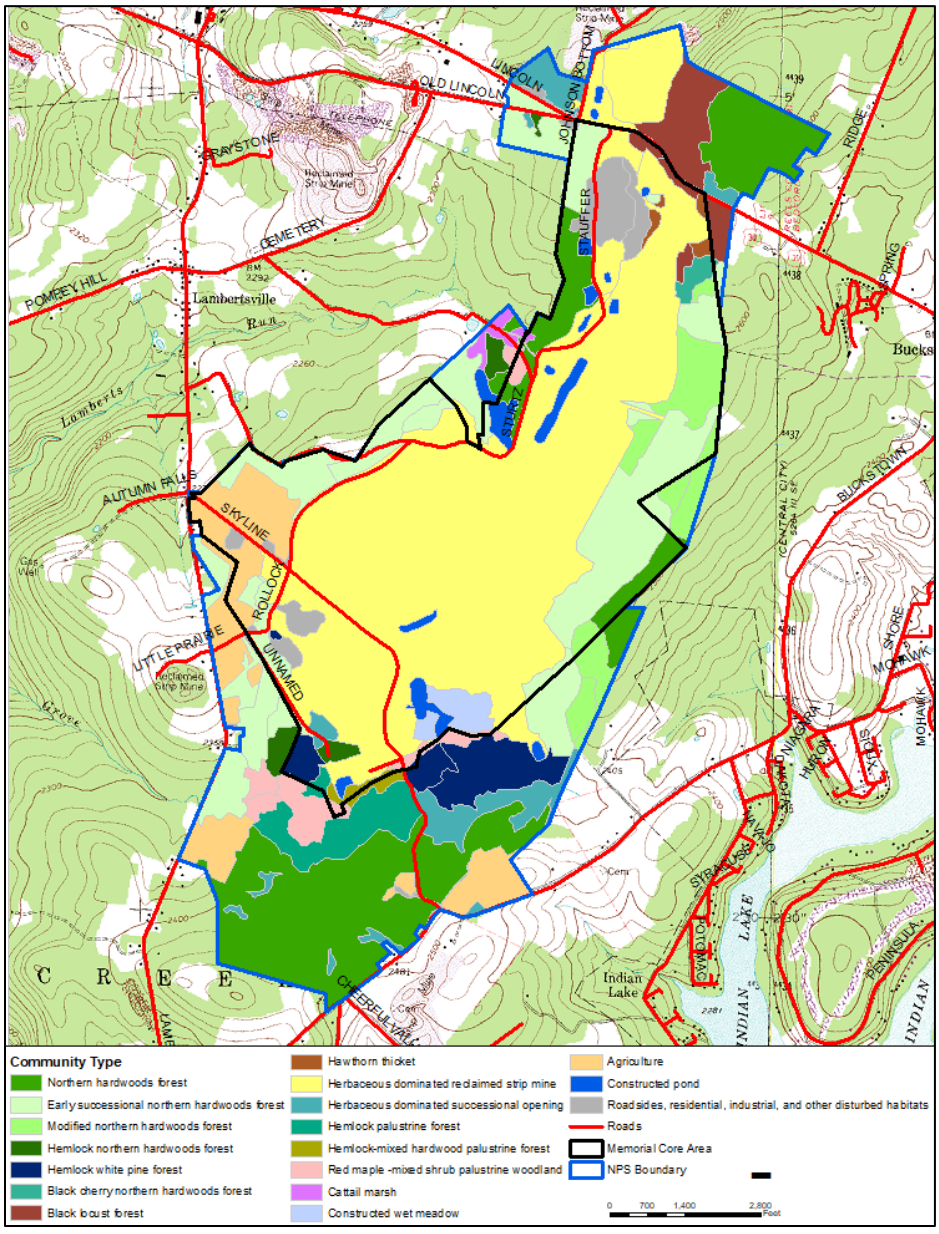

Figure E-1. Original caption for figure (WPC 2005), "Plant community types of the Flight 93 National Memorial; Somerset County, PA 2004 (Base Map: USGS 7.5- minute quad – Stoystown PA)."

The Department of the Interior protects and manages the nation's natural resources and cultural heritage; provides scientific and other information about those resources; and honors its special responsibilities to American Indians, Alaska Natives, and affiliated Island Communities.

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